POST SETTLEMENT VEGETATION
SURVEY OF THE CALIFORNIA DESERT

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INTRODUCTION

The field of vegetation change is vast and diverse. Many forces act upon the vegetation of an area - some physical and some cultural. In the desert, many of these forces have different scales of importance than in more humid climes, and some forces, as will be explained later, have only temporary effects on the predominant vegetation pattern.

The purpose of this report, as outlined in the Bureau of Land Management (BLM) Solicitation No. CA-060-RFP8-49, is to catalog and document, to the greatest degree and specificity possible, the various vegetation changes that have taken place in the California Desert Conservation Area (CDCA) since the first European incursions of the late 18th and early 19th centuries. As shall be seen, the great majority of these impacts have been in the 20th century; the three decades since World War II have seen particularly acute changes to the native cover. The first chapter of this report is a brief synopsis of present desert vegetation patterns. The remainder of the report is divided into sections based on types of vegetative influence within a rough chronological framework. The two appendices are compendiums of species introduced by man and land survey vegetation records.

Vegetation change, particularly as it relates to the California desert, is a field only marginally addressed by academia. It lies in a nether region, hovering between botany,

ecology, history, range management and geography, but almost no one has taken a holistic look at the cumulative effect of all dynamic factors.

Most early work on vegetation change in the deserts was focused east of the Colorado River. About 1900, the Desert Laboratory, sponsored by the Carnegie Institute, was established near Tucson, Arizona and much of the early work on desert ecology (spearheaded by Forrest Shreve and Volney M. Spalding) was performed there. Overgrazing, which resulted in mesquite invasions, high erosion rates, drastic flooding and the lowering of the water table, forced ranchers in Arizona to take notice of the dynamic factors behind vegetation change at an early date. Such works as Hastings and Turner's *The Changing Mile* and Humphrey's *The Desert Grassland* spotlighted these changes, creating strong academic interest in recent years.

California's deserts, however, have not suffered from the above problems; the rains are both too light and at the wrong time of the year for healthy, economically productive grass growth over the long term. During the early 20th century, academicians were also becoming highly cognizant of the many changes in California vegetation, although this interest extended almost solely to the State's coastal valleys, foothills and interior valleys (Burcham, 1957). Much of this interest centered around the many examples of grasses and other forbs which European man had, purposely or not, brought with him. The California

desert was academically ignored for two rather obvious reasons; -- few actual land-use changes had taken place, and casual observers found little cause or need to investigate these changes.

However, great vegetation changes have taken place in the deserts, our State's most recently-treasured land resource. While these changes may not be as large in scale as those that have occurred in the foothills and valleys of California, nor as economically significant as those that have taken place in Arizona, few large areas in our deserts can claim to have kept their plant cover intact. Most of the supposedly stable areas have been impacted by alien species invasions, stolen plants, off-road vehicle tracks or other physical and cultural phenomena.

Lack of early occupants coupled with lack of interest in the California desert's botanical composition, means that we can only guess at the original vegetation carpet observed by our earliest pioneers. Spaniards and Mexicans rarely visited the desert, and most of the Anglo travelers and miners involved in the desert's early history had neither the interest nor expertise to analyze its botanical composition. Railroad and geographic surveyors were more interested in floristics than specific vegetation distribution, and some of the early topographic surveyors (see Appendix B) had little knowledge of desert plant life. Other land surveyors, however, did capable and even excellent vegetation surveys.

Although articles by scientists and travelers noted some of the dominant and unusual plant forms at an early date, the first comprehensive flora of a California desert area was performed by Coville in 1891-93 for the Death Valley region; by this time, grazing (and perhaps overgrazing) had taken place throughout much of the study area. Thus, the "original" (pre-explorer) vegetation of our deserts -- particularly the upland areas where the most grazing took place -- may never be known, except for the more gross characteristics preserved in survey records and diaries.

The Death Valley survey was followed by a series of studies performed in the Salton Basin, under sponsorship of the Carnegie Institution, both before and after the formation of the Salton Sea. Grinnell and others made an extensive biological survey of the lower Colorado River about 1910, and several more limited studies were performed by Clements and others.

It was not until 1935 that a comprehensive flora of the desert was published. Written by Philip Munz, it covered other areas in Southern California as well. In 1940, the first comprehensive botany specifically tailored to the desert region was published; written by Edmund Jaeger of Stanford, it is still one of the acknowledged source books on California desert plants. The floras by Munz of 1968 and 1974 gave botanists an even more comprehensive treatise on desert plants, but, like the 1935 publication, each covers California areas outside the deserts.

A study by W. W. Robbins (1940), more limited in scope, was devoted solely to introduced California plants; it effectively compiled the references to alien plants in the many small floras previously written.

As may be readily observed after reading this study, many important facets of desert vegetation change are not covered. Singular among these is the omission of primary source material from long-time residents in the desert. The BLM study by Ernst (1977) and conversations with various botanists and agricultural officials partially fill this void, but more study should be devoted to this topic. Time and monetary requirements restricted research. Also omitted is any comparison between early land survey notes (Appendix B) and present-day conditions. Aerial photographs were too often unavailable, and time simply did not allow in-person observation of selected sample sites. Utilizing early land survey notes from this study in conjunction with current vegetation data being compiled by BLM, will allow detailed comparisons in future studies. Time constraints restricted the number of primary sources such as diaries, journals, and photographs which could be researched for this report. These sources, which would best augment the data contained herein, are available from title insurance companies, university special collections departments, regional museums and federal depositories. Therefore, this area is highly recommended for future primary research.

CHAPTER I

NATURAL VEGETATION OF THE CALIFORNIA DESERT

A. General Description

The area comprising the California Desert Conservation Area (CDCA) coincides closely with the climatic and vegetation boundary separating the desert from more humid areas of the state. Though researchers do not agree on desert subdivisions, all agree on the sharp boundary between various high mountain ranges bordering the CDCA and the desert. Within the desert Barbour and Major (1977) identify three major botanical zones (transmontane coniferous vegetation, Mojave Desert scrub vegetation and Sonoran Desert vegetation) while other botanists (summarized in Johnson, 1976, p. 133) have designed their own classifications. The geographer Thomas (Aschmann, 1959) identifies three physiographic zones: desert, desert slopes of major mountain ranges, and the Colorado River province. Other geographers have devised their own methods for dividing the desert; Holdridge, Thornthwaite and Koppen, for example, use climatic zones.

That the various classifications are hardly similar is a simple reflection of the several gradational phases of desert vegetation. Most classifications, however, distinguish between the Mojave desert ("high desert"), the Colorado Desert ("low desert") and the Great Basin or basin-and-range section.

The Colorado Desert, situated in the southern part of the CDCA, is characterized by large, almost pure stands of creosote bushes, (*Larrea tridentata*), the existence of various Sonoran desert species such as ocotillo on the bajadas, and the common presence of a wash vegetation zone consisting of acacia, ironwood, palo verde and other species. This area, low in elevation, receives very small amounts of rainfall; the rain that does fall is concentrated into the summer and winter seasons. Most areas with less than five inches of rain per year, have no grasses as dominants in climax areas (Clements, 1935, p. 88).

The Mojave Desert, to the north, offers a dominant-species cover of *Larrea,* supplemented by the burrobush (*Ambrosia dumosa*), and some areas of various cacti in its higher elevations. Rainfall is somewhat greater in this area with some of the higher elevation areas receiving as much as 12-15 inches of rainfall per year. At these high elevations, the dominant role of grasses is beyond question (Weaver and Clements, 1935, p. 537). The Great Basin province, primarily in Nevada but also in the northern CDCA, is primarily dominated by the Great Basin sage, *Artemisia tridentata.* Pinyon-juniper woodlands (*Pinus monophylla-Juniperus* osteospermum utahensis ? *californica*) grow on the higher slopes of many ranges and Joshua tree (*Yucca brevifolia*) woodlands exist in various areas of the Mojave and Mojave-Colorado transition zone. A very lush but narrow belt of vegetation grows along the Colorado River, the only large, perennial

stream in the California desert. Three very small clusters of saguaro *(Cereus gigantea)* grow along this river, significant if only for their size and symbolic importance (Grinell, 1914, p.85)

Desert springs exhibit an entirely different vegetation pattern. In the Colorado Desert, the California fan palm often exists, particularly along fault lines or in shady mountain hollows. Reeds, grasses, and other indicators of water abound at many desert springs; as shall be detailed, springs have proven to be prime areas for vegetative modification.

B. Paleobotanical Background

The present-day deserts of California appear to be static in composition, and indeed, available climatic evidence suggests that our deserts have remained essentially the same for several thousand years. ?

Although it is not the purpose of this paper to investigate vegetation changes that have occurred to the desert in prehistoric times, a brief developmental outline is useful, particularly to help explain existing species and their distribution.

Up until the beginning of the Pliocene geologic epoch, about 10 million years ago, the vegetation of the present-day California desert reflected cooler, moister conditions than those
extant
existent today. Oak woodland, chaparral, sage, and thorn-scrub associations existed in present desert areas; many species were similar to those found in present-day southwest Asia or the

eastern United States, while others were present-day desert ancestors (Mitchell, 1973, p. 18; Axelrod, 1977, pp. 179-186). During the Pliocene, however, the region became more arid driving out all but the hardier species from the present Great Basin and desert. This aridity forced various forest elements to either "climb up" the various ranges, seek out the decreasing number of riparian areas, or die out. As a result of these conditions, the former oak woodlands were gradually replaced by pinyon/juniper, sagebrush or grassland as exemplified by data found in the White and Inyo Mountains (Mitchell, 1973, p.18). Other studies have suggested woodland periods for the Searles Lake area (Roosma, 1958, p. 716), as well as for the Ricardo/Last Chance Gulch portion of the El Paso Maoutains (Clements, 1936, p.109). At that time, the latter site had what would today be an odd assortment of co-existing elements -- *Quercus* spp., *Washingtonia filifera, Cupressus arizonica, Pinus cembroides,* and *Robinia neomexicana* (the latter a chaparral species). A final evidence of earlier vegetation comes from the wood-rat middens in the Lucerne Valley area (King, 1976, p. 227) and the Turtle Mountains (Wells and Bergen, 1967, p. 1642). These data indicate that about 12,000 to 20,000 years ago pinyon and juniper trees grew at lower elevations and in wider distribution than at present.

The Pleistocene epoch was a series of alternating wet and dry periods. Toward the middle of the Pleistocene the present

range of desert dominants invaded from the Sonoran plateau of Mexico (Jaeger, 1938, p. 133). Some of the older species remained, at elevations higher than before; more important, a great many species which were unable to adapt were eliminated (Mitchell, 1973, pp. 18-19). When the current dry period began is an open question. Aschmann (1959, p. 34) suggests that few major climatic changes have taken place in the past 10,000 years while King (1976, p. 236), acting on rat-midden evidence, suggests a date between 7800 and 5800 B.P. Since then, climatic trends have essentially stabilized; data from Searles Lake (Roosma, 1958) suggest that the desert may even be getting moister after a relatively recent (geologically speaking) dry period.

Due to these climatic shifts, a number of species located in widely distributed but small-scale pockets of the desert became relict species. They are located in ecological zones unlike their previous niche, but have adapted to changing conditions. These relicts have been identified in many areas of the desert. Clements, writing in 1934 (p. 56), explains the climatic progression of the entire southeastern California desert area, from bunch grass to desert, through identification of relicts. Prime habitats of these relicts, according to him, are:

> the mesoclines of lower mountains and at altitudes of 3000-5000 feet in the higher areas. Sand and lava fields have formed a refuge for several of the most xeric species, while the most typical of all, *Hilaria rigida*, seems to have been derived directly from the adaptation of *H. jamesii* to a drying climate.

?

Other relicts have been studied in specific areas. On the rocky slopes of Death Valley, *Hilaria, Stipa, Aristida* and *Oryzopsis* spp. have been found (Clements, 1934, p. 43), while at the 4300 foot level in the Avawatz Mountains immediately south of Death Valley, relict prairie exists, containing *Poa scabrella, Hilaria jamesii,* and the more xeric *Triodia, Oryzopsis, Stipa* and *Aristida* spp. (Clements, 1936, p 93 and 125). The Argus Range offers a similarly relict distribution of *Hilaria jamesii, Poa scabrella* and *Stipa comata* (Clements, 1936, p. 125). Cabazon, at the western edge of the desert, until recently also supported a "fine example of bunch-grass prairie" (Clements, 1936, p. 125). This area contained *Stipa speciosa, S. coronata, S. setigera* and *S. eminens, Poa scabrella, Elymus sitanion* and *Koeleria cristata* until it was plowed under, probably in the early 1930s. Nearby *Stipa pulchra,* a similar relict, has been overgrazed almost to the point of extinction (Clements, 1934, Pl. II). *Bouteloua gracilis* and *B. racemosa* are relicts on neighboring mountain slopes (Clements, 1936, p. 125). *Crossosoma bigelovii* is located now only in the canyons of the western Colorado Desert and in Death Valley; it was once much more widespread (Jaeger, 1940, p. 85). Perhaps the most well-known relict species of the CDCA, however, is the native fan palm (*Washingtonia filifera).* They were definitely not brought to California by the Spanish padres, as was once thought (Jaeger, 1940, p. 6); instead, the fan palms survived from a woodland association which existed during the

Pliocene. The climatic changes during and after the Pleistocene forced the fan palm into the isolated niches where it is known now, this process is covered well by Croizat (1952, p. 442-445). Henderson (1951, p. 11-12) disagrees with this hypothesis. Instead, he postulates that only groves along the San Andreas fault are truly "native" and that other groves originated because birds, coyotes or other animals brought seeds there. Considerable debate, however, exists concerning recent changes (Chapter IIB).

C. Stability of California Desert Vegetation

On the whole, California desert vegetation appears to be affected very little by the hand of change; experts in a gross sense agree with this hypothesis. Aschmann (1959, p. 55), in his survey of the persistence of "lands in their wild state" in California, shows that two of the three areas in the California Desert ("desert," and "desert slopes of major mountain ranges") are the least developed in the State (4 and 10 percent, respectively). The Colorado River Valley, the third zone, is an obvious exception. It is 75 percent developed and located entirely outside of the CDCA. Although he does not quantify his data, Burcham (1957) shows similar information in comparative maps on "changes in pristine conditions in California" (p. 80 and 126). He suggests that with the exception of a few agricultural and urban areas the desert has avoided major land use changes between aboriginal times and today. At least one team (Johnson, *et al.* 1948) working on a more detailed study in the Providence Mountains - Clark Mountains area, offer similar information.

They conclude (p. 228) that "to our knowledge these vegetative types (creosote/yucca/fir/piñon/sagebrush) have not been altered by fire, grazing, or lumbering, and we assume they are the climax trees."

Examination of evidence concerning the various desert dominants tends to re-enforce the view that major change has rarely, if ever, occurred. The creosote bush, dominant species over the large majority of California's deserts, appears to be the epitome of stability. Highly adapted and essentially immune to drought, it occupies the warmer, dryer regions of the desert, oftentimes without competition. Its dun-colored appearance has suggested the tiredness of old age to at least one researcher (Parish, 1930, p. 48). In Arizona, the creosote bush has been known to survive for as long as a year with no rain (Hastings and Turner, 1965, p. 271). California plants seem to be even hardier; after the record (1909-1912) drought that hit Bagdad (near Amboy), the by-then-leafless bushes were able to recover (Jaeger, 1938, p. 133). Beatley (1975), gives further indications of this stability; she found that the creosote-sagebrush line proved to be generally static over a ten-year period.

Because creosote bushes can regenerate their stem and leaf structure a seemingly infinite number of times from the same general root base, Vasek *et al.*(1975, p. 11) suggest that many of the plants seen today are the original ones to be established when the community was created.

Upon examination of the available evidence, this stability also holds true for the other dominants. With the exception of a few relatively small areas of overt destruction, the major dominants of the desert -- Joshua tree, Great Basin sage, burrobush, saltbush -- have had their ranges changed very little by the hand of natural or cultural forces in the past 200 years.

Should it therefore be implied that the desert has been entirely static? To the contrary, in addition to the urban and agricultural growth alluded to earlier, a battery of forces -- physical and cultural-- have been at work in the last two centuries. As in times past, natural events including floods, lake creation and dessication, dune transport, and even a few evidences of apparent microclimatic change have altered the plant cover. Parasitism, fallen foliage and snow also have been cited as dynamic vegetation factors (Hunt, 1966, p. 45). Most of these may be regarded as successional events but others represent true vegetation change.

Man's works have been much more complex and far reaching. Both aboriginal man and modern man have used fire. Long-term grazing impacts by cattle, sheep and, particularly, the burro have been widespread. Mines and their developments, farms, and sporadic lumbering have had obvious impacts. Man's roads and canals have both obliterated and encouraged vegetation growth. His presence as a resident or visitor has resulted in such widespread impacts as soil compaction and vandalism; his sense

of comfort and economy have resulted in a long list of foreign, usually unwanted, plant species. Dams have had a marked effect on both up- and downstream areas. In the last 30 years, modern man has accelerated this process of change, both by the previously mentioned methods and by new methods. Plant theft, once considered an occasional pastime by the uncommon lover of the desert, has become a virtual plague threatening many species with extinction in portions of their range. Off-road vehicle use has also mushroomed since World War II creating true deserts out of once pristine bajadas and dune areas. Finally, air pollution, once restricted to the southern California metropolitan areas, has been arriving at some desert areas in dangerous levels in recent years. The vegetation, tough and adaptable as it is, may well be sickening as a result.

Because of this bevy of activity, man's dominance over the desert appears to be strong indeed. In areas such as the Imperial Valley, an entirely new order has replaced the natural cover, and the Coachella Valley's plant cover has been so altered that McHargue (1973) considers it all but hopeless as a future plant-ecology research area. Other areas are nearly as strongly impacted.

To be sure, many of the dynamic forces outlined above are only temporary intrusions into the climax vegetation cover. From an idealistic, purist standpoint, it may be argued that most of the vegetation can eventually recover from impacts with the exception of town development, mining, dams and certain plant introductions. But successional recovery is long-term, often

requiring hundreds of years. Because mankind has been carrying on so many activities over such a short timespan in an area with very slow vegetation recovery rates, ever greater acreages of the desert are becoming involved in some stage of successional recovery. Thus, it appears to be a moot point as to whether some vegetation change is transient or permanent. Accordingly, both will be addressed in this report; specifics of these impacts are elaborated upon in the following chapters.

CHAPTER II

NATURAL INFLUENCES ON VEGETATION PATTERNS

Water, particularly erosion caused by flooding is the permanent influence on the desert's natural ground cover. However, other changes have resulted from rising and falling water levels, both groundwater and surface. The changes are apparent particularly as they affect spring sites, blowing sand, freeze-thaw relationships and changing salinity levels near dry lake beds. Being natural events, most of these tend to be successional and balance out over time, but their effects are often felt for many years due to the desert's slow ability to heal itself.

A. Floods and Erosion

Several areas, most markedly in the Colorado River Valley, have been periodically affected by flooding. However, the Imperial and Coachella Valleys, Mohave River Valley and, to a lesser extent, all mountain and bajada slopes have also been affected as a normal part of their erosion-deposition cycles.

Until the early 20th century, the Colorado River was a wild river, undammed throughout its entire length. As a result, it experienced springtime flooding of varying proportions. The vegetation of this area, therefore, had adapted itself to periodic flood conditions; while the entire floodplain was not flooded annually, most species had the ability to withstand floods or re-seed themselves once a flood had passed.

Before dam-building took place, the major growth along the floodplain bottom was cottonwood *(Populus fremontii)* and willow *(Salix nigra)*. Emory, during his 1846 crossing of the river at Yuma, noted that "the growth of the riverbottom is cottonwood, willow of a different kind, *Equisetum hyemale* (scouring rush) and a nutritious grass in small quantities" (Emory, 1848, p. 100). Both of these dominant species abounded at that time with willows forming a thicket along the river margins. The higher grounds were especially favorable for the mesquite. Emory found it more luxuriant than anywhere previously on his travels from Missouri. He also noticed several species of *Boerhaavia* and one of *Kallstroemia*, and found mistletoe on the branches of the mesquite.

The lower Colorado River valley was first investigated scientifically in the early 20th century by a team, under Joseph Grinnell, which rafted from Needles to Yuma. After describing the sinuous pattern of the stream within the floodplain, his report (1914, p. 59) states:

> The most important phenomenon ... is the progressive movement of these loops down the valley. The result is that in a short period of years, the major portion of the river's floodbottom is worked over in the path of the irresitable and continual shifting of the channel.
>
> The effect on the flora is obvious. Only in the curves of the valley sheltered by abutting hills are trees given a chance to reach advanced age. Therefore, only willows and cottonwood appear because they grow fast. During flood stage, trees are swept away on the riverbanks, and hundreds of acres are appropriated in a few days within a short distance.

> As a result, bands of growth are formed. Small one-year-old plants appear along the inner curves of the river, while behind them, dense two-year stands are located. Older vegetation towers behind the two-year growth.

Like Emory, Grinnell described a "second bottom" along the river, a bench above the normal high-water mark where mesquite bushes and salt cedar grew along with a saltbush association containing pickleweed and iceplant (Grinnell, 1914, pp. 61, 79). A belt of arroweed often grew between the river bottom and this "second bottom", usually a quite solid growth immediately below the high-water line. *Baccharis glutinosa* var. *guatemote* was the only other consistent member of the bottomland association, though screwbean was also occasionally observed (p. 70). The water itself, which was laden with mud, was unable to support an algal flora (p. 68). There were few marshes along the Colorado before the various dams were built; evaporation occurred too quickly to allow marshland development (p. 72).

Because the vegetation of the Colorado River area was so remarkable compared to that of the surrounding countryside, many researchers have commented on it. Lippincott (1902, p. 157) briefly described the area, as did Thompson (1929, p. 731), and both of these descriptions effectively mirrored those found earlier. By 1950, Marks observed that *Tamarix* readily moved into the clay wallows left by the retreating river; this appears consistent with the views of Grinnell. Woodward (1976, P.22) also noticed stands of willow and cottonwood along the river, as had previous investigators. She found this distribution only occasional.

As a result of unusually high floods along the Colorado River during historic times, its waters have periodically crested the banks near Yuma and travelled down into the Salton Sink. The Salton Sink is known to have contained a lake (Lake Cahuilla) until 300-400 years ago (MacHargue, 1973, p. 45), and to have experienced partial inundation from the Colorado River in 1890, 1891 and 1892 (Norris and Carrico, 1978). There was another flood during the spring of 1905, and although it probably would have been sufficient to overflow into the Salton Sink even without man's intervention, ill-timed repair work on the principal diversion structure supplying the Imperial Valley caused a complete rerouting of the river. For this reason, the Salton Sink received most of the flow of the Colorado River for the next two years. The flow gouged out 40-foot deep channels along the Alamo and New Rivers and caused flooding throughout the valley which washed away miles of vegetation, small lakes and other features (Norris and Carrico, 1978). The flood, not surprisingly, changed the dominant plant communities along the major Imperial Valley rivers. Each channel had originally been covered with mesquite and the New River contained cottonwood and willows (Davy, 1902, p. 2). However, post-flood vegetation was dominated by an association of *Scirpus paludosus* and *Typha latifolia*, with a secondary growth of willow and cottonwoods in both channels (Parish, 1914, pp. 91, 96).

The flood waters terminated in the Salton Sink, eliminating much bottomland vegetation. Before the 1905 - 1907 deluge, much of

the vegetation away from the saltpan had been creosote bush scrub, though forests of mesquite and screwbean had also existed (Jaeger, 1940, p. 97). The flood created a much larger sea than that existing today. Its surface reached a maximum level of -196 feet (82 meters) below sea level, thus covering a large belt of land to a depth of 40 feet (13 meters) above the present water surface. Its 1907 volume of 16 million acre-feet was almost three times the present volume.

Other floods more localized in nature have also created long term changes. Though flash floods denude a number of small mountain-slope and desert-wash environments every year, occasional large floods often have more widespread effects. For example, several evidences of the 1916 flood, Coachella Valley's largest in historic times, still remain in canyons near Indian Wells and Rancho Mirage (McHargue, 1973, p. 36); a March 1927 flood "greatly altered" the bed of the Whitewater River, particularly below the mouth of Whitewater Canyon. A 1962 flood in Thousand Palms canyon washed away a small dam and lake, and a year later a similar flood "substantially altered" the floor of Pushawalla Canyon, uprooting a large number of fan palms. Thompson noted that after the 1916 floods (which were destructive in cismontane as well as desert areas), there was an abundant, if temporary growth of *Suaeda suffrutescens* and *Sesuvium portulacastrum* around the various "dry" lake beds. Thompson also noted that in flood-prone areas, the creosote bushes grew larger than elsewhere, attaining

heights of six to eight feet. Plant life in the rare desert marshes that contain perennial surface water are also heavily impacted by floods; such Mojave-River ferns as *Azolla filiculoides* and *Berula erecta* (Munz, 1974) which require sluggish water, or reeds such as those near Afton Canyon, may be entirely eliminated by a large flood, or be cut back severely and transported to another, less favorable area.

Because of the uprooting created by the runoff from the annual desert rains, a series of successional phases exists which are fairly well-defined in the areas on the margin of Coachella Valley. These phases have been described by McHargue (1973, p. 249-253). On steep, rocky slopes, the first species to invade after a disturbance may well be the one which eventually dominates, for example, creosote is both the pioneer and climax species along steep hillsides behind Palm Springs, Rancho Mirage and Desert Hot Springs. On the dry bajadas of this area, the primary pioneer plants are *Coldenia palmeri, C. plicata, Croton californicus* var. *mohavensis, Dalea emoryi, Eriogonum inflatum, Palafoxis linearis, Stephanomeria pauciflora,* and *Stillingia paucidentata.* Sandpaper plants (*Petalonyx thurberi*) are pioneers on the sandy bajadas and washes, sweetbush (*Bebbia juncea*) are pioneers on the rocky bajadas and washes, and cheesebush (*Hymenoclea salsola*) are pioneers in washes and on moist, sandy bajadas. Pioneers.

These pioneer species keep their relative importance over time; therefore, true climax vegatation patterns are rarely developed in these situations (McHargue, 1973, p.253). This trait is also

suggested in studies performed in other parts of the creosote bush scrub community. According to Vasek, *et al.* (1975 p. 12), *Hymenoclea salsola* and *Euphorbia polycarpa* are the principal pioneer species in the Newberry-Lucerne Valley areas. In the Great Basin province, three species have been cited by Wells (1961, p. 670) as pioneers: *Thamnosma montana, Hymenoclea salsola,* and *Salazaria mexicana.* These species also have been known to be pioneers in dry areas cleared by man.

B. Spring Dynamics

Many of the larger springs in the CDCA are perennial, and have existed in wet and drought years alike for centuries. Others, however, are unreliable at best and oftentimes highly ephemeral.

The existence of a spring, inasmuch as it indicates a very high water table, provides habitat for both large dominants and a variety of lesser species. However, some springs have dominated or become so changed as to provide only shallow groundwater thus eliminating the shallow-rooted herbaceous species. This has undoubtedly occurred many times in the past 200 years, but there is little specific data on this subject. Many spring sites dry up so completely that all spring-related vegetation dies; other springs may re-emerge for awhile without re-acquiring those species.

Several generalities concerning the vegetation around springs in their primitive state are in order. Jaeger (1938, p. 183) speaking about California desert springs in general, claimed that mesquite was a "sure indication of groundwater, found near almost all springs." He even suggested that the past availability of water at any given spring site could be tested by judging the age of the mesquites. Though the study area and timeframe differ, McHargue (1973, p. 65) disagrees with Jaeger's statement. McHargue states that vegetation varies a great deal among Coachella Valley fan palm oases. He says that the fan palm itself was the only common species in the 23 oases he surveyed.

Parish (1914, p. 96) suggested that "blind springs" (areas at shallow groundwater) like those on the Indio-Mecca flats, carried a vegetative complex similar to that of nearby surface spring sites. This "blind spring" complex was composed of black willows *(Salix nigra)*, delta cottonwoods *(Populus macdougalii)* with *Baccharis glutinosa*, and an outer margin of saltgrass *(Distichlis)* sod.

Because of the great human attraction of fan-palm oases, oasis ecology has changed a great deal in recent years and demands special attention. Purely natural forces have been at work in some areas; several oases in the Carrizo Corridor -- one of which was the first area known as Palm Springs -- were eliminated during the 19th century (Edwards, 1969, p. 73) and this natural dynamics continues (Vogl and McHargue, 1966, p. 533). However, a host of other factors have been at work on them. It is possible that aboriginal firing affected their distribution (Aschmann, 1977, p. 135). Periodic fires to the fronds appear to induce growth, while fires which overheat the crown tip can destroy the tree. It is doubted that widespread early destruction took place, however, for fire is a biotic factor for which palm oasis vegetation is well adapted (McHargue, 1973, p. 66).

In more modern times, these palm groves have had mixed success. Parish (1914, p. 101) counted only two indigenous groves in the Salton Sink area (generally defined as that area below sea level); these included two trees at Dos Palmas (where

several dozen now grow) and six on the alkaline flats near Mecca. He alluded to rumors that there were others, but he did not find them. Parish also found *Washingtonia* spp. at Agua Dulce and Figtree John Spring, along with black willow and delta cottonwood trees. However, Parish was of the opinion that the palms in those groves were planted by the Indians, and cites the long native American occupancy there to substantiate it. Most groves have experienced changes in the general number of palms growing, Henderson (1951) has assisted by making censuses of palms in many groves.

Other groves appear to be more obviously planted. A 1914 photo of the Cottonwood Spring in Joshua Tree National Monument (Harter, Pl. III) showed no signs of palms but some 40 years later the species was listed at the spring (Adams, 1957). In many desert residential areas, they are attributable to plantings since the 1920s. Likewise, the palms at Corn Springs have been planted (Sering, 1978) as have some that have naturalized in Kern County (Clarke, 1977, p. 128). In some cases, man-caused fire and other acts of vandalism have reduced the number of palms, but culturally induced destruction has frequently ruined surrounding vegetation more than it has palms (Jaeger, 1938, p. 189). In Death Valley, a very small amount of wild palm seedling development has taken place directly related to the planted date groves near Furnace Creek; wild palms are now located "here and there in washes near these groves" (Hunt, 1966, p.34). However,

these palms, along with other date palms from Baja California and the Coachella Desert, should not be confused with the native species of fan palm.

C. Zonal Vegetation Dynamics

A few, scattered references exist to suggest that broad-based general vegetation shifts are going on at the present time; most observations of this change were made in the Death Valley area. Hunt (1966, p. 38) states;

> The changes in [Death Valley's plant] distribution are continuing. At several places, salt-tolerant phreatophytes are spreading at the expense of the less tolerant one, xerophytes are spreading at the expense of the phreatophytes and on some marginal kinds of ground the phreatophytes are receding.

In Hunt's discussion of the pickleweed (a highly halophytic shrub), this increasing salinity with elevation is repeated;

> ...some evidences of retreat of the panward edge of pickleweed was noted at four localities: at the northeast foot of Trail Canyon fan, the foot of Johnson Canyon fan, the cove south of Copper Canyon, and locally along the west side of Cottonball Marsh. In these areas are many salt mounds which probably once were pickleweed mounds.

however, this zone movement has not all been upward. Hunt states:

> desertholly is expanding fanward at the expense of the saltgrass (in Death Valley) because gravel is being worked from the fans onto the sand of the carbonate zone.

General changes in vegetation are also reflected by examples of mesquite deterioration. These appear on page 42 of Hunt (1966):

> In Death Valley, in many places around the saltpan, the mesquite stands are deteriorating. At the north end of the valley, where Salt Creek discharges to the saltpan, there is a belt of sand dunes with honey mesquite. Several of the mesquite trees at the west end of the

> belt and at the east end are dead; the present area of live trees is less than half what it has been. At the foot of the fan at Blackwater Draw are several patches of dead mesquite. North of Tule Spring are numerous dead mesquite trees west of the present stand. Mesquite trees more dead than alive are in the wash high on the gravel fan three miles south of west of [sic] Bennetts Well. Whether the general deterioration is attributable to decrease in water supply or increase in salinity of the groundwater is not known.

Periodic, hard freezes also may play a role in changing limits of a plant's margins. McHargue (1973, p. 68) quotes from a 1937 study by Turnage and Hinkley, who noted the large number of damaged Coachella Valley plants after the January 1937 "killer freeze." The study did not imply, however, that the cold snap was the only dynamic factor working on the plants. The desert lavender *(Hyptis emoryi)* population is exemplary in that it expands in "warm" years and decreases in "cold" years because of frost damage (Jaeger, 1940, p.223). Beatley (1974, p.24) suggests that dynamic forces are working in the transition zone between *Larrea* and *Artemisia* in southern Nevada; she notes a large number of dead *Larrea* plants within this zone. Apparently, the plants were killed by low temperatures; *Larrea* is extremely sensitive to heavy snowfalls. Slight as it might be, McHargue (1973, p. 85) also noted a reduction in the range of one species during his study. Early in his work, he had found a single ironwood tree *(Olneya tesota)* at the mouth of Thousand Palms Canyon (the extreme northwestern end of its range), however, the plant died during the course of his study. Jaeger (1940, p. 44) noted that both the hollyleaf spurge *(Tetracoccus ilicifolius)* and the golden carpet

Check out trees Dn

(Gilmania luteola) were dying out due to the increasing desiccation of Death Valley; on the other hand, the bractscale *(Atriplex serenana)* and thistle sage *(Salvia carduacea)* were invading into the western Mojave Desert. The crucifixion thorn *(Castela emoryi)* is known to have spread westward to the Colorado Desert (Jaeger, 1940, p. 123); it is not known how recently this occurred.

D. Sand Movement

Advancing sand dunes have played a slight role in the modification of plant environments. A study performed by Leslie Dean identified 17 California desert dune systems, 4 of which appear to be advancing. In direction, the Cadiz Valley dunes appear to be moving southeast; the Chuckwalla Valley dunes eastward (in some locations); the Salton Sea barchans eastward toward and into the Salton Sea (Dean, 1978, pp. 49-61). As explained in a study by WESTEC Services, Inc. (1977, p. 11), the Algodones dunes are probably not as active as they once were, however, they are still advancing. A recent estimate (p. 126) suggests an eastward movement of about 10 cm per year. At one time, shortly after line construction, the dunes are reported to have forced the Southern Pacific to reroute its tracks.

The stabilizing of dunes may also affect vegetation patterns to a small degree. Hunt (1966, p. 32) states;

> ...pickleweeds [a mile south of] Gravel Well have advanced away from the saltpan and invaded some old dunes that once supported mesquite. It is also common in the furrows of the old Borax Workings near Shoveltown and at East Borax.

Arrowweed, apparently, takes advantage in a similar way:

> Where mesquite has died and where the dunes have become reduced in height and stabilized, arrowweed has moved onto the ground formerly occupied by the honey mesquite (Hunt, 1966, p. 39).

CHAPTER III

ABORIGINAL AND EARLY HISTORIC VEGETATION INFLUENCES

A. Aboriginal Influences Upon the Desert

Considering the length of time in which aborigines are known to have lived and traveled in the desert, their impacts upon the land have been slight. There are few sources which have noted aboriginal impacts, and perhaps this is a reflection of the general lack of vegetative disturbance caused by aboriginal presence.

Known impacts have occurred from native American plant gathering, firing, agriculture, and possibly some species redistribution. However, most of these impacts were short-term, and thus cannot be generally noticed today. More important, the great majority of the desert was left almost wholly untouched, with the exception of the minor impacts created by the many desert trails.

Most of the clans occupying the desert practiced a hunting and gathering economy. Actual removal of plants rarely took place, however, and then only on an individual or small-scale basis such as *Agave* collection. Homer Aschmann, the noted cultural geographer, made an overview of all native impacts upon the desert. He concluded that:

> An Indian band occupied almost every permanent water source [in the desert] at least occasionally. The edible *Agaves* may even have been seriously depleted near the waterholes by native exploitation. However, today this land is either completely untouched, or else it has been completely modified [but only by recent historic developments] (Aschmann, 1959, p. 43).

Fire was also an agent of vegetation modification by aboriginal groups. As described in Chapter II, California fan-palm groves may also have been periodically burned. Some researchers have hypothesized that the groves cannot exist without fire; in Baja California, the natives were known to regularly fire fan-palm groves. The above examples of firing, however, probably did little long-term damage to the plant cover, and may have enhanced the vegetative cover in some of the lusher desert areas.

Burning as a method of plant manipulation and enhancement was apparently widespread amongst native Americans. As early as 1792 naturalist and explorer Jose Longinos Martinez (Simpson, 1938, p. 51) noted that:

> In all of New California from Fronteras northward the gentiles have the custom of burning the brush, for two purposes; one, for hunting rabbits and hares (because they burn the brush for hunting); second, so that with the first light rain or dew the shoots will come up which they call pelillo (little hair) and upon which they feed like cattle when the weather does not permit them to seek other food.

Colorado River Indian (Yumans) regularly cleared their agricultural plots by burning (Castetter and Bell, 1951, p. 140). Other historic accounts by Gaspar de Portolá (Bolton, 1927, p. 129), Father Junipero Serra (Tibesar, 1955, Vol. 1, p. 101) Albert Evans (1873, p. 208) and John Randolph Spears (1892, p. 77), clearly indicate that native Americans throughout southern California used fire to clear seed gathering areas, to destroy mistletoe in mesquite groves and to enhance fruit production.

Aschmann (1959, p. 48) summarized the general consensus that fire was only a limited factor in altering the desert when he concluded that:

> Modern authorities are still uncertain of the long-range effects of repeated burning in specific situations. Did it cause the degradation of a complex chapparral to the less useful chamise or coastal sage association or did it expand the oak-grassland parks? Most likely shifts in both directions occurred in different climatic and ecologic situations. In any event, the wild landscape the European explorers found was a product of millenia of such disturbances.

In addition to gathering and burning, some aboriginal groups, (such as the Mohave, Kamia and Cahuilla), also modified the natural vegetation patterns through farming. Most of the farming areas were in periodically-flooded areas along the Colorado River or at the southern end of the Salton Sink. However, all evidence of native American plantings has been washed away by seasonal flooding.

Smaller less extensive agricultural areas were established around villages in portions of the Coachella Valley, where walk-in wells provided water for irrigation. (Norris and Carrico, 1978) Certain species of legumes, watermelon, corn, and squash were grown in the kitchen-garden type plots.

Farming native Americans may also have introduced several new plant species to the desert. Charles Hunt (1966, p. 3) hypothesized that sacaton grass in Death Valley had been brought there by Yuma Indians, because the grass, useful in several ways, was known to exist in all other areas frequented by them.

Other species, such as chia, were carried by natives as a food source while traveling. Because very little is known concerning the adaptability of such species previous to the historic period, the importance of aboriginal transport as a food-distribution source can only be guessed.

Assuming that the aborigines had as much success transporting seeds to new areas as did early European travelers, their effect was very slight. Aschmann (1976, p. 42) concurs, suggesting that the Indians' vegetal exploitation neither helped nor hindered the range of species they commonly used. But previous climatic conditions, changing distributions or preferences of food sources, and other variables may have strengthened the importance and effects of native American distribution of plants.

In the final analysis it is difficult to make any conclusions concerning the importance of seed transport in changing the distribution of a species (Carrico, 1978). Similarly, the effects of Indian burning, native American farming and depletion of plants species may have been so subtle as to go unnoticed. Alternatively, alteration since European settlement may have been such that we will never be able to address the issue.

B. Domestic Grazing Impacts (Cattle and Sheep)

Cattle have been grazing in the California desert since the first Spanish explorations in the late 18th century. Although its more favored areas have been in continuous use for something over 100 years, the California desert, with its extremely dry climate, has not supported the number of ranchers that neighboring desert areas have.

It cannot be definitely ascertained whether overgrazing has changed California's plant cover to any significant degree. The detailed early data are simply not there. Clements (1934, p. 59) makes a strong point that the three scrub communities of the southwest (sagebrush, desert scrub and mesquite) were all created out of grasslands largely due to man's actions -- chiefly grazing and fire within the historical period. Aschmann (1959, p. 43) does not think that the sporadic grazing on the springtime ephemerals affected plant distributions. Certainly, the gullying and arroyo-cutting which characterize badly overgrazed areas in more humid climes (Bryan, 1925) are not present here to a great extent. However, some species invasion has taken place and several of the introduced species are especially suited to overgrazed lands. In the eastern Mojave there may have been some cholla and yucca invasions of lands with a previously healthier grass cover (Bell, 1978), and some stands of blackbrush may be indications of past overgrazing areas (Thorne, 1978). However, these points have been neither proven nor disproven.

Cattle were first driven across the desert with Anza's 1774 expedition, but there was very little grazing in our deserts, either along trails or by free-ranging stock, until the American invasion of California in the mid-to-late 1840s. For the next 30 years, the various trail routes -- Old Spanish Trail, Mojave Road, Weaver Trail and Southern Route -- were the principal passageways of cattle into California, and constituted the primary grazing areas in the CDCA (Norris and Carrico, 1978, pp. 31-40). During the drought years of the early 1860s the Mojave River became the grazing grounds for many coastal ranches (Bard 1973, p. 49; Burcham, 1957, p. 153). By 1870, several cattle operations, centered on the desert side of the mountains and in the Antelope Valley had appeared (Edwards, 1969, p. 50). By 1880, the industry had grown larger until it occupied more acreage than it does today (Ernst, 1977, map 1).

It is not the purpose of this paper to document a history of grazing in the desert, particularly because Paul Ernst (1977) has already done such a creditable job. In his survey of California range lands, Burcham (1957, p. 112) suggests that outside of the western Antelope Valley, only an insignificant portion of the desert was economically worthwhile for grazing. Perennial grasses
Eurotia lanata Atriplex
along with winterfat, saltbush and mesquite browse, he explained, offered good to excellent forage; but between limited quantity and the lack of water, range grazing was not economically effective. However, as Ernst's descriptions show almost every basin has

experienced some grazing. The fact that more grazing did not go on in an area probably implied that the grass conditions were quite poor. Even minor grazing probably unbalanced conditions enough to allow what!? species invasion and other detrimental effects.

The many spring sites along the trails into cismontane California were the first areas to be impacted. The trailside vegetation was also affected to a lesser degree. The Southern Route, the first route to experience grazing pressure, went from Yuma south through Mexico to the site of present-day Calexico, then through the Carrizo Corridor to Warner's Ranch. Very little grass has existed along the route in recent years (Quincey, 1960, p. 100) and early diaries indicate vegetation was no healthier in years past. General J. W. Kearny, in November 1846, noted that, "We crossed the Colorado about 10 miles below the mouth of the Gila, and marching near it about 30 miles farther, turned off and crossed the desert -- a distance of about 60 miles -- without water or grass." Emory (1848, p.103) wrote:

> I have noted the only two patches of grass found during the "jornada." There are scattered, at wide intervals, the *Palafoxia linearis, Atriplex, Encelia farinosa, Daleas, Euphorbias* and a *Simsea,* described by Dr. Torrey as a new species.

One of these grass patches was at the crossing of the as yet-unchannelled New River. There, Emory found species of *Arborescens* ? along the lake borders, and on the upper clay borders of the river he found gramma grass, which yielded on "evanescent but highly nutritious fodder." The other site was at

Cariso [sic] Creek, a mile-long running stream, where there was "cane, rush, and a coarse grass, such as is found on the marshes near the sea shore." Additionally, he came upon "a patch of sun-burned grass" a day's walk west of the Salt Lake [near present-day Silsbee], the Salt Lake being "bordered by mesquite trees and a chenopodiaceous shrub." Emory, as a member of Kearny's party, was among the first to utilize the Southern route.

W. P. Blake travelled along the same route less than a decade later. In the meantime, thousands of Argonauts had passed through; as a result, Blake found the conditions of all the wells and waterholes deplorable between the Colorado River and Carrizo Creek (Blake, 1856, p. 245).

Conditions were somewhat better for travelers along the Mojave Road. Fremont was one of the first to travel portions of it, and after reaching the Mojave River in April 1844, in an area generally believed to be close to Cajon Pass, he noted that

> In 15 miles we reached a considerable river, timbered with cottonwood and willow, where we found a bottom of tolerable grass. Between us and the Colorado River, we were aware that the country was extremely poor in grass (quoted from Casebier, 1975, p. 164).

Although it is difficult to site Fremont's diary locations on modern maps, he appears to indicate that the river sank into sand in places but was wet again in spots along the lower Mojave River. These "wet spots," probably near present-day Barstow, are currently dry. He noted acacia and screw-bean

mesquite along several portions of the lower Mojave (Casebier, 1975, pp. 165-6).

By the 1850s others had traversed this route. In October 1859 when Winfield Scott Hancock left Los Angeles for Fort Mojave, the condition of the grass across the desert to Fort Mojave was generally not good. Therefore while he took 25,000 pounds of freight for the fort, he also carried 15,000 pounds of forage, most of which would be consumed by the teams on the trip (Casebier, 1975, p. 103). At the "Upper Crossing of the Mojave River" (Joseph Winston in Casebier, 1975, p. 175), while at the probable site of Camp Cady, he found "plenty of wood, water and grass -- a considerable extent of good pasture land. One to two hundred tons of hay could be cut here annually." While all parties crossing through Afton Canyon were impressed by its surface water, little mention was made of grass growth. Lt. Williamson noted, however, in his 1853 survey report, the "abundant growth of mesquite trees" in the plains east of Afton canyon (Casebier, 1975, p. 169). At what must have been Soda Springs, Williamson in 1853 noted,

> We had found...several fine springs. Around these was good grass. The camp was moved here, and the animals were refreshed at once again having as much to eat as they wanted." (Casebier, 1975, p. 170)

Winston also visited the site in October 1859, noting it a "five to six acre site of rush and salt grass" (Casebier, 1975, p. 175),

while Heintzelman in 1859 described there being "bunch grass tolerable plenty" (Casebier, 1976, p. 12).

At Marl Springs, Winston found "plenty" of water and some grass about one mile southeast of the spring. Heintzelman, in 1859, noted grass on the hills to the north of the springs (Casebier, 1976, p. 12). A large cleared area, perhaps a quarter mile across, had been created around the spring site by 1863, but by the 1960s the vegetation appeared to have fully regrown (Casebier, 1975, pp. 116-117) Heintzelman also reported that there was abundance of grass between Rock and Marl Springs during his trip of May, 1859 (Casebier, 1976, p. 12).

At Rock Spring, Winston reported that "water, grass and cedar were all plenty;" in the same year, Heintzelman found "an abundance of gramma and other grasses." At Pah-Utah (Casebier, 1976, p. 12), there was "grass on the hill to the right [north] of the springs, as also three miles on the bottom below the mouth towards the river." Finally, just west of the Colorado River was Beaver Lake, noted by Heintzelman as "having some grass...at the foot of mountains."

The vegetation along the Old Spanish Trail is somewhat less well documented. At Resting Spring, Fremont reported a "spring of good water, and sufficient grass for thirty horses." Judging from early reports, Bitter Spring had little grass growth to accompany its poor quality water (Casebier, 1975, p. 166). Regarding the trail in general, Ernst (1977) mentions that "many animals, principally horses and mules, used the

trail," but their pressure on the range was limited to trailside areas.

Much of the available data on early trail conditions have not been retrieved (see Introduction). Through Mr. Casebier's extensive research, however, much of the data concerning the Mojave Road are readily available. Reports on other routes are replete with vegetation data in the diaries and newspapers of the time, but much cross-checking needs to be done to confirm the geographic accuracy of spring and grass locations mentioned therein.

Other areas almost certainly had better stands of grasses then than now. In the Antelope Valley, it was reported that "during the summer, sagebrush filaree and other vegetation would grow so luxuriously as to make ideal hiding places for immense droves of deer and antelope" (Settle, 1973, p. 26). The northern edge of this valley was less lush. As viewed by William Brewer, traversing from Fort Tejon to Fremont's Pass (Oak Creek Summit), in May of 1864, the area was:

> ...covered with a scanty and scattered shrubby vegetation. It does not look so naked as much of the San Joaquin and Tulare plains that are not desert. The shrubs are of craggy growth, and belong to species which can withstand the severest drought.
>
> The most notable shrub of the region is a species of yucca *(Yucca gloriosa)*. Another species of yucca...grows on the drier mountains and is now in flower. It has a tuft of bayonet-like leaves on the bottom... Of far less interest is the creosote bush, every part of which stinks, making the whole air offensive. Sage bushes *Aartemisia)* make up most of the vegetation, however. Many volcanic knobs arise [to the east], each perfectly bare of vegetation (Brewer, 1966, pp. 388-9).

As further evidence of previously lush grass conditions, Thompson described the grasses in the upper Lanfair Valley in about 1920 as "more abundant then in almost any locality in the Mojave Desert, and several hundred cattle are grazed" (Thompson, 1929, p. 668). He also described good bunch-grass growth in the northwest part of Superior Valley in 1921 and reported that some cattle fed on this grass (Thompson, 1929, p. 246).

One known overgrazed area, the Anza-Borrego area and vicinity was overstocked twice in about 1900 and again around 1940, each time for three to five years. It "reduced many perennial grass populations to mere skeletons of their former numbers," according to Jim McCain, quoting his father (John McCain) an early pioneer (Ernst, 1977). Floods aggravated the situation, turning once productive meadows into unproductive washes; at the time of settlement most of the now dry canyons had perennial running streams. When John McCain was asked why his early cattle operations were so successful, he said "The whole damn country was wading in bunch grass. And it was like that all across the desert, even in the mountains." The Fish Lake Valley was also overgrazed for a time during the 1940s, and some forage species in the Hunter Mountain area underwent severe pressure around 1940 (Ernst, 1977).

Other evidences of overgrazing have been difficult to pinpoint. It is known, for instance, that there was "increasing competition for grazing land, for cattle and sheep" in the 1850s to 1870s in Antelope Valley (Settle, 1973, p. 23). It is also

known that the peak of overgrazing on the Arizona ranges occurred in 1891 (Hastings and Turner, 1965, p. 146), but whether this signified a similar trend in the California desert is unknown. Finally, sheep are known to have wintered annually in the northwestern Mojave Desert [presumably Antelope Valley] or as far south as the San Gabriel or San Bernardino Mountains between 1865 and 1905. In spring they were moved to the Owens Valley, then back to the Walker Pass area or by other routes to the San Joaquin Valley (Burcham, 1957, p. 169). Because of the close cropped grazing of sheep, overgrazing may well have occurred along their route. Overall, the impact of grazing upon the desert's productivity may well have been immense. Describing the relative carrying capacity of "original" rangelands versus present (1936) ones, Burcham cited a study which showed: a loss of productivity in the pinyon/juniper lands of California from 3.4 acres per animal unit-month (aum) to a "current" figure of 8.4 acres per aum, a loss of range capacity in the sagebrush belt from 2.9 acres per aum to a 1936 figure of 8.9 acres per aum; and a Pacific bunchgrass (including the Antelope Valley) loss from 2.2 to 4.5 acres per aum. However, none of these vegetation associations are wholly or even significantly in the CDCA and the widespread creosote-dominant desert association is ignored entirely.

Species distribution offers other evidence of overgrazing. Woolly galletagrass *(Hilaria rigida)*, a native to both the Mojave and Colorado Deserts, is a valuable forage grass usually

grazed to the ground. Successive years of close grazing have removed many stands that are now represented by only scattered colonies (Crampton, 1974, p. 140). Relict stands of *Stipa pulchra* protected by *Opuntia* are the only evidences of previous grasslands in now overgrazed pastures near Cabazon (Clements, 1934, Plate II). Some varieties of beavertail cactus (*Opuntia basilaris*) have recently extended their range where overgrazing has weakened the soil for support of less hardy species (Clarke, 1977, pp. 102-104). Crampton (1974, p. 75) identifies cheatgrass brome (*Bromus tectorum*) as a good indication of range deterioration in previous bunch-grass areas. It invades overgrazed areas easily, but in healthy stands of native bunchgrass, it is a poor competitor. *Erodium cicutarium* is an important invader of overgrazed areas (of the desert saltbush association), and it also invades abandoned farm lands. It is known that the desert plants *Amsinckia tesselotta*, *Trichostema lanceolatum*, *Gutierrezia lucida*, *Haplopappus* spp. and *Chrysothamnsus nauseosus* are also indicative of overgrazed areas but most grow in undisturbed situations as well (Clarke, 1978). *

Schismus ~~barbatus~~ (Abu´mashi), is easily the most widespread of the many indicators of overgrazed areas. An alien species, it invaded almost the entire desert in the short space of about 15 years (1945-1960). It occupies grazed and non-grazed areas alike, although it is especially prevalent in open, overgrazed situations (Clarke, 1978). A native which has been endangered as a result of

overgrazing is Indian ricegrass (*Oryzopsis hymenoides*) which is a valuable forage plant for desert livestock, it does not recover well from grazing pressure. Reseeding attempts, moreover, have generally been unsuccessful (Crampton 1974, p. 119). Clements feels that overgrazing has even spread the range of our most widespread dominant *Larrea tridentata*. In a 1936 paper on vegetation dynamics, (p. 90) he stated that;

> in the wake of overgrazing, [*Larrea*] has spread extensively to replace the vanishing grasses and today its proper climatic region can only be determined by the presence of relict grasses on the one hand and of its peculiar desert associates on the other.

The Clark Mountain area has also been overgrazed in the past. Because of relatively favorable conditions for grass growth, recovery of the native vegetation has taken place (Priggy, 1978), and the only evidence indicating overgrazing is a lingering disfigurement of the shrubs in the area.

C. Feral Grazing Impacts

As long as animals have lived there has been feral animal grazing in the California desert. All non-carnivorous animals in the desert get their entire solid diet from desert plants with no known long-term destructive effects on vegetation.

The feral burro, however, appears to have thrown this ~~delicate~~ system off balance. An exotic, it is far more ecologically adaptable than other animals with indiscriminate dietary habits that are endangering several desert species.

The burro has been on the California desert since the first expeditions crossed it in the late 18th century. Burro distribution was strictly controlled until the early 1860s when, following a series of small mining strikes along the Colorado River, they began to be abandoned (Woodward, 1976, p. 4). Specifically bred for stringent environmental conditions, they quickly adapted to the land along both sides of the River. domestic burros were a major component of the prospector's existence and thus were widespread over the desert until mining began to taper off approximately 1910). As a result of a mining boom in the northern deserts between about 1905 and 1910, the burros gained another base of operations in the territory around Death Valley. In this fashion, burros spread to many desert ranges. Only in the Saline Valley are the burros not miner's strays; rather, they were planted there in the 1930s by a college which did not attempt to round them up again until they were too widely distributed for economical re-gathering (Ernst, 1977).

In their capacity as miner's pack animals, the burros damage to plant life was quite minor and limited to areas around mining sites. In most areas, their numbers has remained fairly stable in the 20th century because ranchers, hunters, and wildlife managers (each for different reasons) periodically "cropped" their ranks, (Woodward, 1976, p. 4). However, the Death Valley region was particularly inaccessible and by 1939 their population had increased to 1500; the Park Service reduced their number to 700 at that time. Over the years, they have removed a total of 3578 burros, mostly by shooting.

By 1953, a series of burro protection measures began to be put into effect. California enacted a limited burro protection law in that year and, in 1957, a burro-protection zone was established that encompassed almost all of eastern Inyo County (Woodward, 1976, p. 138-9). Burros gained federal protection in 1971 via the Wild Horse and Burro Act.

These laws, of course, had a marked effect on the burro population. Up until the 1950s, the burro population had stayed fairly level. A 1953 writer, probably exaggerating, said that feral *Equus asinus* was almost extinct in California, and McKnight, in 1958, claimed that burro populations were "much less than in past decades" (Woodward, p. 138). Since 1957 (Inyo County) and 1971 (other desert areas) their numbers have been burgeoning.

As of 1973, burro populations in California were as follows: 80 in the Chemehuevi Mountains area; 100 in the Whipple Mountains

area, 50 in the Palo Verde Mountains; and 40 in the Picacho Peak area (Woodward, 1976, p. 7). Burros have not been tallied in the Death Valley area, however, the largest, most concentrated grouping appears on both sides of the Panamint Mountains. Other areas of concentration include: The Funeral Range; Saline Valley; Granite Mountains; Little San Bernardino Mountains; Providence Mountains, and possibly other desert ranges (Ernst, 1977).

Presently, burro populations are ecologically destructive only in the Panamint Mountains (Woodward, 1976, p. 142), Saline Valley and Waucoba Canyon (Dedecker, 1978). In Ms. Woodward's study area, the carrying capacity of the range was just being met in 1973. As a result, the ocotillo had been broken off, palo verde showed obvious browse lines, and other plants similarly suffered, nevertheless, plant reproduction continued unimpinged. However, the future looks bleak for the plant life in these areas. Sexually active and with a low mortality rate, the Chemehuevi burro group is expected to double by 1980 and continue its geometric growth progression beyong that date. The Death Valley area is already well past its carrying capacity.

Several ecological effects from burros exist in the Chemehuevi Mountains area. They may have eliminated the perennial grasses from the area; the absence of an historical record prevents knowing whether or not these grasses ever originally existed. Because these burros prefer the desert wheat grass or woolly plantain *(Plantago insularis)* it may be diminishing in importance. Secondarily and rather oddly, the burros prefer dead or withered

portions of arrowweed and palo verde branches. They can be truly indiscriminate in diet and fecal examination shows that they eat a wide variety of plant products.

In the Panamint Mountains and surrounding areas, conditions are worse. Severe drought conditions appear to exist. Within one mile of water utilized by burros, four species of perennial grasses were eliminated and grasses were seriously reduced up to five miles away (Woodward, 1976, p. 141). Studies by Moehlman in 1972 and Welles and Welles in 1961 conclude that there is no hard evidence that burros befoul water holes or strip the land. However, the quality of their personal observations and, perhaps, the time lapse since those studies were performed may negate some of their conclusions today. Dedecker (1978) stated that many springs in Inyo County, particularly Last Chance Spring, Gold Belt Spring and Waucoba Spring have been entirely stripped of vegetation. She reported that the rare *Astragalus lentiginosus* var. *sesquimetralis*, limited to Sandy Spring, is under severe danger of extinction by burros. Thorne (1978) reported that the Panamint daisy (*Enceliopsis covillei*) is dying off for the same reason. Current studies at several BLM sites are measuring the extent of this impact.

D. Mining Impacts

Mines have rather obvious impacts on desert vegetation; the predominant vegetation is irrevocably altered both at the site of a mine and upon the tailing pile. Camps are also often organized around mining operations; vegetation impacts there will be covered in Chapter IV, section B.

Over 5000 mining claims and more than 1000 working mines have been established in the California desert. The great majority have been small-scale and ephemeral, however, large ones have had significant impacts.

The majority of large desert mining operations have only slightly affected the vegetation mantle because they were operated on dry lake beds and did not have large tailings areas. Salt, potash, soda ash, related chemicals, along with some borate products and gypsum have all had minimal impacts on plant cover. Mines with large impacts are: Borou and Old and New Ryan (borate); Mountain Pass (rare earth elements); Fish Creek and Midland (gypsum); Oro Grande, Victorville, Creel, Cushenberry (cement); and Eagle Mountain (iron). Observations at desert mine sites indicate that, because there is nothing resembling a true soil layer on the surface, plant life rarely grows back either in an open pit or on tailings. Examples from other states show that with expensive replanting efforts it is still difficult for plants to take hold in such a hostile environment.

Assessment work which precedes the actual mining operation have resulted in few vegetation impacts until recent years.

Today, however, some mine operators perform their assessment work with a bulldozer, baring bedrock areas as they crisscross the land. This has taken place at Lee Flat, south of Saline Valley (Dedecker, 1978) and at other locations.

E. Agricultural Impacts

One of the greatest sources of vegetation and floristic change in the desert is agricultural development. Agriculture has existed on the desert since the early 1870s when homesteads began to be taken up "here and there" in the Antelope Valley (Settle, 1973, p. 26). Agricultural acreage is located in three major desert areas: Antelope Valley, Imperial Valley and Coachella Valley. Lanfair

Homesteading, using dry farming methods, grew in the Antelope Valley area throughout the 1880s and 1890s. A major ten-year drought hit the region between 1895 and 1904, forcing many to abandon their lands. Fluctuations continued with the 1920s, since then farm acreage has been more stable.

Irrigated agricultre began on a modest scale around Palm Springs and Indio in the 1880s and 1890s and Coachella Valley agriculture, primarily between Indio and Mecca, grew slowly until 1948. At that time, 27,000 acres were under irrigation; acreage quickly grew to over 62,000 acres with completion of the canal that year. (McHargue, 1973, p. 53). The Imperial Valley developed much more quickly, growing from a wasteland in 1900 to over 500,000 irrigated acres in 1925 (Norris and Carrico 1978, p. 57 and 68).

With the exceptions of a few sections in the southern Coachella Valley, most irrigated desert acreage is still being used for irrigated agriculture. Some currently-abandoned lands in the Coachella Valley were in use during World War II and have subsequently

"salted in" while other abandoned lands appear to have entirely regrown their nature mantle. The only Coachella Valley areas with genuinely undisturbed vegetation are selected Indian Reservation lands (McHargue, p. 55).

Most of the basins in the Mojave Desert have supported some agriculture; these homesteads were taken up between 1900 and 1920. Major areas are shown on a map in Norris and Carrico (1978, p. 67), although additional homesteading sites occurred in the Koehn (Kane) dry lake area (Thompson, 1929, p. 219) and at several isolated sites. Most homesteading ventures died quickly as a result of floods, drought or loss of water rights; few areas are still active today.

Agricultural areas have also been established in other desert locations. Some are highly capitalized deep-pumping operations, established relatively recently in desert basins. These include the operations in Fish Lake Valley, Fremont Valley and Harper Lake. A few pump-irrigation areas, such as a small area near Needles and along the Mojave River, utilize river flow as a water source. Palo Verde and Bard Valleys receive water directly from the Colorado River by irrigation canals.

Agriculture affects vegetation in three major stages. First, the original mantle of vegetation is removed and replaced with another, seeded type. Because of the excellent niche this open land provides, a second phase occurs as many weeds (usually aliens) are able to gain a foothold in a field or on its margins.

This is particularly true of irrigated fields. Finally, should the agricultural area be abandoned, pioneer plants invade the open ground and begin the process of succession. Often these are the same species that inhabit pioneer situations on the nearby natural landscape but some species of plants appear to be especially suited to abandoned field situations. In the more favored situations, such as Lanfair Valley, vegetative regrowth of all but the largest plants has taken place within 40 years; these regrowth rates may be even faster in Antelope Valley (Stoirs, 1964, p. 163). Regrowth will take a longer period under less favorable environmental situations.

Some of the plants which are particularly favored by agricultural situations are listed in Appendix A.

F. Lumbering

Perhaps because trees are such a rare commodity in the California desert, there has been a relative scarcity of desert lumber operations. Pinyon, juniper, cottonwood and yucca are among the largest plant species in the desert, and each has been cut but not to a large degree.

The first and probably most celebrated example of lumbering occurred during the 1870s in the Panamint Mountains. The Modock and Defense mines needed material for their smelter at Lookout; however, the nearby Argus Mountains had few significant trees. Therefore, large numbers of trees, primarily pines, were cut to be turned into charcoal at the kilns in Wildrose Canyon. This lumbering probably lasted about two years leaving a large scar which is still plainly visible on the north slope of Rogers Peak (Murphy, 1972). Trees may have also been denuded within Wildrose Canyon itself; if so, this lower area has substantially regrown.

Though complete data are largely lacking, many other pinyon pine areas have also been denuded. For instance, large stacks of wood on Wild Horse Mesa testify to previous cutting. Bare areas around Barnwell (Manvel), north of Goffs, were doubtless due to miners who needed fuel for both ore processers and domestic needs. Many other pinyon-juniper areas located close to mining towns can be expected to have had similar effects (Gallegos, 1978).

Mesquite is another major species which has often been cut. It was utilized most around the turn of the century. In 1914, Grinnell wrote:

> Man's occupancy of the [Colorado River] region has affected the mesquite association more than any other. The great value of the mesquite trunks for fuel has led to its practical disappearance as a tree along much of the lower course at the river. The steamboats...are said to be chiefly responsible for this depletion. Several pumping plants contributed to this demand for fuel. Mesquite trees are very slow of growth; tracts of stumps now mark many areas where luxuriant groves once stood.

The foregoing appears to be only a few of the uses. Benson states (1941, p. 730):

> Mesquites... at one time were of great value as timber in desert areas where no other wood was available. [They are] still much used for fenceposts and firewood... and used for trinkets and novelties. Their gum is sold in the manufacture of gumdrops and mucilage. Their seeds were used by the Indians and white pioneers for making flour and as a source of bread. They were one of the staple desert foods.

(J. OSTEOSPERMA)

Like the mesquite, the desert juniper (*Juniperus californica* var. *utahensis*) has also served as a source of fenceposts and fuel (Jepson, 1923, p. 79). Pinyon pines, dominant in the same general ecosystem as the juniper, have probably received more recent modification. They appear to be losing some of their lower-elevation range in the mountains south of the eastern Antelope Valley; whether this is due to lumbering, air pollution or other factors is not clear (Wilson, 1978).

Because cottonwood trees *(Populus fremontii)* have had little economic value, very few have been cut. Portions of their range were lost when inundation occurred due to dam building along the Colorado River. The only known instance of recent cutting was during the late 1960s and early 1970s in the Imperial Valley. Farmers there felt that many of the cottonwoods located along the riverbanks and canal banks were taking too much water and, therefore, cut them (Lowe, 10/2/78).

A final genus to be exposed to lumbering is the *Yucca*. The Atlantic and Pacific Fibre Company was formed in the 1880s to cut many of the "yucca palms" (Joshua trees) in the southeastern Antelope Valley as part of a proposed pulp-making operation. The wood was processed at a mill in Ravenna but spoiled while being shipped to England (Settle, p. 29). For a time during the 1920s, the wood of the Joshua tree was used in the construction of Hollywood movie scenes (Stones, 1964, p. 150). While it is doubtful if either of these altered the local vegetation permanently, the slow regrowth rates of Joshua trees suggests that these areas may have been altered for many years.

More recently, the lumbering of yuccas (primarily *Yucca schidigera*) has become a more consistent economic enterprise. The leaves are used to make soap, shampoo, root beer and other items. The major activity areas for this are Southern Pacific lease lands in the Vontrigger hills as well as in other areas (Priggy, 1978). As of late 1976 a total of 3800 acres was being actively harvested. The Southern Pacific claims that operations are being run on a

sustained-yield basis, with no plants cut over six feet in height ("Desert Plants Being Removed," 1976). Nevertheless, long-term plant depletion may occur.

G. Road Impacts

Roads are an obvious break in the natural plant cover extending into seemingly every area of our deserts. Roads, in the form of wagon roads, have been in the desert since the 1840s; automobiles began to travel desert routes about the time of World War I. The completion of a paved, well-connected network of roads, however, did not occur until the late 1930s, and many of our smaller, secondary roads were not completed until the 1950s (Norris and Carrico, 1978). Railroads create many of these same impacts and pipelines also have similar effects, as explained later in this section.

The construction of a road, particularly a paved road, has three major effects: 1) it eliminates the natural plant cover from the road surface and the road shoulder (if one exists); 2) the disturbed ground opens up new areas for pioneer plants, particularly exotics (why not natives?), to gain a foothold; 3) as a barrier to drainage, it changes the health and vigor of existing plants alongside the road (Johnson, *et al.*, 1975, pp. 106-107). In a very few places, specifically, urban areas along freeways, there are exotic species planted by the highway department, but these do not normally escape.

The elimination of the plant cover alone make roads a major force in vegetation change. Although vegetation removal is usually limited to the road and its immediate shoulder, roads such as that crossing Eureka Valley are bladed well away from

the road, giving a blighted appearance to the vegetation (Dedecker, 1978).

In 1975, the Riverside BLM office estimated that 22,236 km of roads existed in the California desert. If it is assumed that these roads average 5 meters in width, their total acreage would cover 11,064 hectares, or an area slightly larger than a standard township; these roads, of course, are most numerous in urban areas. In addition, some of General Patton's war training sites remain heavily roaded, as do areas impacted by the 1964 Desert Strike operation (Sering, 1978). Many military runways, located in several parts of the Desert Training Center, as well as near Mojave, on Cuddeback Dry Lake and in other areas (Colling, 1978), deserve inclusion in this category.

Roadsides serve as fertile open areas where pioneer species, particularly alien ones, can take root. They are thus similar to abandoned agricultural areas, canal banks, and garden areas in their attraction for non-climax species, (see Appendix A).

Three of the several studies that have been completed on roadside vegetation, shed light on the ability of alien species to grow in newly disturbed areas; mixed results are reported. A study by Frenkel (1970), concentrated on one Great Basin vegetation site; upon examination of the ruderal vegetation in an area largely devoid of alien species, he found that 7 of the 11 existing species were introduced annuals. In a study by Johnson,

et al., (1975), 4 introduced species were noted in the 23 existing species; however, the adjacent control area contained the same 4 species. In fact, the introduced species did increase their ground cover along the roadside, but the fertility of the roadside environment also caused native species to slightly increase their ground cover. Regrowth rates and plant succession were also studied in a slightly different situation -- a pipeline construction zone (Vasek, *et al.*, 1975). There, a three-step phase to vegetation recovery occurred. In agreement with other researchers, however, they concluded that it is debatable if a climax vegetation is ever achieved (see Chapter 2A).

From the limited evidence available (chiefly from the study by Johnson, *et al.*), it appears that plants forming the original ground cover have only limited success regaining control over the roadside, even along older roads. Road maintenance departments, stray automobiles and other cultural forces combine to keep many roadsides in a pioneer sere much of the time. A study currently in progress by Dr. Vasek of the University of California, Riverside may be able to shed some light on native regrowth, particularly as it applies to roadside cholla.

The roadside serves as a modifying agent for plants growing alongside it. This is usually manifested by an increased growth of bushes immediately beyond the roadside's edge. Frenkel called this phenomenon the "edge effect," and it happens in most desert areas to a greater or lesser degree. The study by Johnson *et al.*

showed a marked increase in the production and number of the two dominants *(Larrea tridentada* and *Ambrosia dumosa)* in an area south of Lucerne Valley. Because of the concentration of water along the "edges," total biomass production along a road cross-section was far superior to that of a control area, even when the bare road was taken into effect. Both paved and unpaved roads were used in this analysis; paved roads produced 2.7 times as much biomass as unpaved roads and 6.3 times the biomass of the control area (Johnson, *et al.*, p. 111).

Results have been mixed concerning which species best take advantage of the "edge effect." In the study by Johnson *et al.* (p. 110), most species responded positively to the extra moisture availability, but most of the roadside biomass increase was due solely to the growth in *Larrea tridentada.* Wilson (1978) found the largest examples of *Larrea* in the entire western Mojave Desert along roadsides in the Lucerne Valley area. Frenkel uncovered an entirely different response to the edge effect when he discovered a "striking line" of the native shrub *Chrysothammus nauseosus*, pioneering along the road edge. Johnson, *et al.*, noted that as road width increased the "edge effect" also increased, but not proportionately to the extra moisture provided by the bare road.

H. Plant Invasions

Compared to other sources of impact, plant invasions are not a dramatic, easily identifiable change to a desert's vegetation pattern. Rarely are such invasions asked for by man, and rarely are they as noticeable as are his impacts, for instance, a farm or road.

The cumulative effect of desert invaders, however, is enormous. Robbins (1940) counted 360 alien species in California, at least 10 percent of which are situated on the desert. As shown in Appendix A, many more alien plants have been identified. The great majority of them do not venture out into the open desert as escapes. The few that have, however, have done much to transform the desert's major plant compositions. Several of these invaders will be described more fully in this section.

The origin of the desert's invading species explains much of its cultural history. Unlike most of its native shrubbery which has slowly evolved from other species to the south and east, most of the desert's alien species developed in the past 75 years, after having arrived from Europe via cismontane California.

It appears logical to assume that several of our alien species propagated after having been planted by early desert travelers. Historians know that Alarcon was carrying many seeds with him when he sailed up the Colorado River in 1540, and Padre Kino may well have had seeds with him when he crossed over into California in 1702. Indians are known to have carried on a vigorous trade across the desert as well (Burcham, 1957, p. 186).

However, no known species can be traced to such journeys; conversely, the arrival of most alien plants was done in a rather ignominious fashion. They arrived in the desert in a hundred ways -- bundled in flax seed, packed into railroad car crevasses, lodged within lambs' coats -- all quite unintentional. Although a few California aliens, such as *Avena fatua, A. barbata, Bromus mollis, Erodium* spp. and *Medicago hispida* are valuable, most alien species are economically poor to worthless. At best they are a nuisance to mankind, ruining gardens or requiring weed-control expenditures; at worst they can be genuine pests, hurting cattle and diminishing the forage value of the range (Burcham, 1957, p. 125).

Because of the desert's close proximity to coastal California, most of the aliens have come from western Europe. Fortunately, we know a great deal about the origins and distributions of these weeds through the efforts of many competent botanists; these origins are noted in Appendix A. The major effect of the desert invaders is that the large bajada areas, once clothed in perennial bunchgrasses, have been largely replaced by annuals. This invasion took place first in cismontane California where large amounts of the California Prairie and Oak-Woodland native vegetation were similarly replaced by less productive annuals (Burcham, 1957, p. 125). This invasion has taken place somewhat more recently in the California desert. But the cause(s) of this change and particularly the role of overgrazing in creating the environment

for change are not definitely known at this time. Many of the principal invaders also played a role in changing the moist coastal areas while other species appear particularly well-adapted to the desert's more stringent ecosystem.

The largest and most obvious invader to the desert is the tamarisk. It is known by a variety of common names (desert tamarisk, French tamarisk, flowering tamarisk, salt cedar, or athel tree) and scientific names (*Tamarix aphylla, T. pentandra, T. ramoissisima*); this complexity of names is addressed in a 1967 article by B.R. Baum. The tamarisk is excellently adapted to the California desert, occupying virtually every area with water fairly close to the surface, it can tolerate a moderate amount of salt. Virtually every desert botanical study area includes the tamarisk. They thrive in: several places in Death Valley (Hunt, 1966, pp. 33 and 45); the Coachella Valley (McHargue, 1973, p. 97); springs in the eastern Granite Mountains (Thorne, 1978); campgrounds throughout the CDCA (Sering, 1978); alongside the Colorado River and at the southern end of the Salton Sea (Kuchler, in Barbour and Major, 1977). Tamarisk is less abundant in: the Vallecito area (Quincey, 1960, p. 100); other washes of the
BEAUCHAMP ?
western Colorado Desert (Beacham, 1978); desert washes on the east side of the Chemehuevi Mountains (Woodward, 1976, p. 20); the Saratoga Springs area (Bradley, 1970, p. 115); washes near the Algodones dunes (WESTEC Services, 1978, p. B-15); and at various spring sites in the Antelope Valley (Stones, 1964, p. 162).

Its overall distribution, as far north as Idaho and as high as 11,000 feet in elevation, shows its adaptability (Robinson, 1965; Marks, 1950, p 18; Bowser, 1957, p. 415). Because of its extraordinary seeding powers, it grows at some places with little or no tree competition. Along the Colorado river, however, solid banks of tamarisk have almost completely replaced previous stands of willow, arrowweed, poplar and baccharis (Bowser, 1957, p. 415). In Death Valley, they have displaced mesquite in several habitats (Hunt, p. 34).

Originally, the tamarisk was an introduced plant used as a shrub for windbreaks or for ornamental purposes on desert ranches (Robbins, *et al.*, 1941; Jaeger, 1938, p. 188). They were not listed in Coville's Death Valley botany of 1891-93. Since 1900, however, their spread has been "phenomenal," according to Bowser (p. 415). Parish, in 1913, noted only one tamarisk plant in the Salton Sink -- this at the Travertine Terraces -- but away from the Sink. A broader survey, shortly after Parish's survey, identified them as abundant at Furnace Creek, near the Salton Sea, at Thousand Palms Oasis, and at Cache Creek (Robbins, 1940). The trees have become introduced along many miles of railroad track in both the Coachella Valley and the Eastern Mojave Desert (near most Santa Fe sidings), and, from there, they have seeded themselves in many adjacent localities (WESTEC Services, 1977, B-15). By the 1930s, they had become distributed over most of their present range (Clarke, 1978). As an example of how quickly

they can spread, one tamarisk was observed at the mouth of Cow Creek in Death Valley in 1957; two years later there were 12 (Hunt, 1966, p. 33).

The Russian thistle also warrants special attention among desert plant invaders. Scientifically, it has been called either *Salsola iberica* AND or *Salsola paulsenii*. According to Beatley (1973), *S. iberica* was the only recognized species until 1968, when Munz recognized the speciation. *S. iberica* grows primarily ?? in areas over 6000 feet in elevation, with *S. paulsenii* below 4000 feet and a mixture in the intermediate area. It is *S. paulsenii*, or barbwire Russian thistle, which is of major concern as an invader. It is widely distributed in the desert in several major ecological habitats.

Salsola came to the California desert from southeastern Russia and central Asia by way of South Dakota (Beatley, 1973, p. 226). It was introduced into California after several adjoining states had been invaded, and first occurred in Lancaster about 1891 (Robbins, 1940, pp. 42-43). Probably brought in by cattle cars, it first appeared on the streets of the town near the tracks and soon spread into a large portion of the Antelope Valley. Already a recognized pest by 1895, it appeared at Cajon Pass by 1901 and was collected in Barstow in 1913. *S. paulsenii*, now thoroughly established in Death Valley and southeastern California (Beatley, 1973, p. 226), is particularly abundant on abandoned farmlands of the desert saltbush association (Robbins, 1940, p. 43). Although it is generally regarded as an escape, it

appears to prefer disturbed areas, and in a recent study in the Antelope Valley was not observed invading undisturbed areas (Wilson, 1978).

Schismus barbatus is another major invader of the desert. Concentrating on open desert ranges, it is now common in both the Colorado and Mojave Deserts. Crampton (1974) recognized two species, *Schismus arabicus* and *S. barbatus*, both common throughout the CDCA. However, *Schismus barbatus* appears to be the more troublesome in recent years.

Schismus is a native of southern Europe, India and Africa. It was introduced to the CDCA by way of southern Arizona, and was noted at Huron, in Fresno County, during the 1930s. Robbins (1940, p. 33) reported that the above stand was the only one noted in California by 1940.

However, *Schismus* growth since then has been phenomenal. Oscar Clarke, a longtime observer and student of the plant, suggests that the plant may not have even entered the state by 1935 and that a few plants may have existed by 1945, but it was able to fully overtake the desert by 1960 (Clarke, 1978).

For several years, it was seriously considered that the eucalyptus tree would also become a prominent alien to portions of the desert. Many substantial groves had been successfully planted along the semi-arid California coast by the turn of the century, so it was assumed that the "eucalypts," as they were called, could just as easily enrich some of the semi-desert areas. The October, 1902 issue of *Forestry and Irrigation* proclaimed the following:

> The covering of the now untillable, treeless portions of the semi-tropic section of America with such trees as Eucalyptus, which will yield fuel, timber and other useful products, and also furnish protection from the sun, from winds, and from floods, or otherwise ameliorate existing climatic conditions, is certainly an achievement greatly to be desired. The chief value lies in the possibilities they hold for the reforestation (?) of the bare, dry mountainsides of the desert country, and for the protection of irrigated streams; it gives promise of great future usefulness in the semi-arid portions of our continent (pp. 513-515)

Despite such fanfare, no eucalyptus groves were ever planted in the California desert.

CHAPTER IV

RECENT INFLUENCES ON DESERT VEGETATION

A. Dam and Canal Building

Dams, like mines, have a rather obvious, marked effect upon desert vegetation. There are several major dams in the general study area, not in the CDCA itself, which will be mentioned briefly. Several other dams exist within the CDCA.

There are four major dams: Parker, Palo Verde, Imperial, and Laguna. Laguna and Palo Verde were the first dams to be built about 1910 and 1920, respectively. They are both actually weirs, whose purpose is not to store water but merely to raise the water level so that settling tanks at the beginning of an irrigation system can operate efficiently. Parker and Imperial Dams were built in the mid-to-late 1930s; made of concrete, they are more typical of dams in other areas. A fifth (minor) dam, Headgate Rock Dam, is located south of Parker Dam and holds back a small volume of water.

The early dams, built before Boulder (later Hoover) Dam, did little to stem the annual spring flood of the Colorado. Dam construction, however, did affect river vegetation in two ways, setting a pattern that would hold for future dams. First, backing up the river killed much of the vegetation behind the dam. Grinnell, visiting Laguna Dam shortly after it filled, reported that all of the "first bottom" was killed and covered over. The "second bottom" of mesquite was also killed, leaving only dead stalks alongside the river; in their

stead, appeared large mud flats, "growing up to arrowweed" (Grinnell, 1914, p. 61). Grinnell found the scale of mesquite mortality puzzling for the plants were also unable to survive in the larger washes. Only at the mouths of these washes did scattered examples of mesquite extend away from the river, and then only for a quarter mile or less.

The other major effect of dam construction is manifested below the dam site. Dam-building caused the river channel to be deepened, so that what had formerly been first bottom land soon became second bottom land with appropriate changes in vegetation quickly following (Grinnell, 1914, p. 67).

Among the several dams that have been built within the CDCA, the largest are on the desert's edge and were built for the Owens Valley aqueduct. Haiwee and Fairmount reservoirs were built about 1910 for the Owens Valley project. Copper Canyon and Hayfields reservoirs were built for the Metropolitan Water District aqueduct around 1935. Because each of these dams was constructed in areas with less vegegation and less hydrologic activity than the Colorado River dams, impacts on plants were less notable. The destruction of a stand of crucifixion thorn in Hayfields Reservoir is a notable exception (Jaeger, 1940, p. 12). In addition, several check-dams have been constructed across desert bajadas, and many berms on the higher elevation sides of road and railroad rights-of-way may be included in this category. The effects on plants in most of these situations appears to be similar to roadside

situations. However, no detailed research efforts have explored vegetation dynamics in these situations.

Canal building also has affected plant life, though not in any extraordinary way. Berms on the side provide some areas for pioneer species invasion; and some desert plants that grow nowhere else inhabit the canal banks (see Appendix A). Canal construction removes original vegetation. Canals, themselves, are free of vegetation unless they are shallow and slow moving. If the canal is cemented, much or all of the canal bank vegetation zones are also eliminated. Canals are valuable in their capacity as a carrying agent for the seeds of many desert plants, both native and alien.

Direct Human Impacts

Direct human usage has caused many interruptions in the desert's plant cover. Streets, waste and garden areas in towns, home building sites and vandalism have been mentioned earlier in this report.

The impacts from town development change the plant cover in two ways. Similar to road and canal construction, development eliminates plant growth on the site of the proposed building and also provides a fertile habitat for invading species, particularly in street, dump and garden areas. These open areas have been generally described by Anderson (1952, p. 145) and others. As Appendix A shows, these open areas provide the only invasion corridors for some desert aliens.

The effect of town development on plants has been significant though hardly disastrous. Although perhaps 500,000 people now live in the CDCA (Norris and Carrico, 1978, p. A-1), their homes, businesses and other buildings are concentrated into a few small areas of the desert, primarily on the cismontane margins. In such areas as the Coachella Valley, the vegetation has been significantly impacted, due to both the numbers of houses and the practice of clearing the vegetation prior to construction work (McHargue, 1973, p. 59). This bulldozing has also occurred in the Milpitas Wash area (Sering, 1978). Desert housing developments, particularly in five-acre tract areas, do not appear to have disturbed large amounts of plant cover. Many of the residents of desert communities value the adjacent plant life as an integral part of desert living.

Vandalism and the trampling resulting from heavy human traffic also have affected the desert to some degree. As noted in Chapter II, many of the more accessible palms in the Coachella Valley-Mecca Hills area have been vandalized by burning, slahing and other wanton acts. In other places, particularly campgrounds, seed and plant development has been impaired by foot and auto traffic.

Other miscellaneous human impacts also occur. The proposed solar energy facility near Daggett will have a particularly large area of impact, perhaps approaching the size of a small city (Sering, 1978). Such impacts may well increase both in number and size, in the future.

Man's activities have had an influence in insect populations in several areas. In a section of the eastern Antelope Valley adjacent to an agricultural area (around Little Rock), there has been a noticeable decrease in the cholla range in recent years. When observed at least one and perhaps several of the plants were heavily infested with ants (Wilson, 1978). The cause of this infestation, the only one thus far reported on the desert, can only be speculated. ??

C. Impacts of Fires

Since Anglo occupation of the desert, beginning in the late 19th century, the uses of fires, if not the scale, has changed. Because the total amount of biomass has not significantly changed since aboriginal times (see Chapter III), neither has the land's tendency toward firing. The land does not easily carry a fire. Even in the relatively lush high desert woodland and scrub association, "only after an unusually wet series of years is the plant cover dense enough to maintain an extensive brush fire," according to Aschmann (1959, p. 42).

This type of fire is known to have occurred only twice. In the 1940s much of the north slope of the Kingston Mountains was fired, from which the pinyon and juniper has still not recovered (Priggy, 1978). A similar fire, probably in the last five years, laid bare portions of the Old Woman Mountains adjacent to the Old Woman statue (Gallegos, 1978).

Other reported fires, often intentionally set, have been smaller in scale. Dr. Ruth Wilson has noted several areas of firing in the Antelope Valley, including a section of land along West 20th Street between Avenues "K" and "L." Several areas of the lush roadside strip along Interstate 15 were burned probably by passing motorists. One of these burns occurred just south of Bear Valley Road (Wilson, 1978). Other burned acreage is located about six miles northwest of Glamis (Adams *et al.*, 1970, p. 696), near the mouth of Snow Creek southwest of Whitewater and in numerous town dump areas. Firings in palm groves were discussed in Chapter III.

In general, fires are not a predomonant aspect of desert plant ecology. However, when they do occur, the area's plant life generally will be depressed for many years, although species such as the Joshua tree often resprout soon after burning.

Not really
PGR

D. Plant Theft

Insignificant until a few years ago, the theft of plants from the desert has recently become a major problem. Between the growth of the southern California population and urban residents' increasing desire for desert plantings in their yards, the deserts have suffered -- particularly from cactus stealing. These plants are stolen primarily for commercial purposes and are intended for an Arizona market. The piracy has grown gradually in the last 30 years. Arizona's strict cactus-theft law, enacted in 1974, compounded the problem for several years. Arizona suppliers were forced to transfer their operations to California until a similar law was enacted here in 1976 (Booker, 1978).

Plant piracy occurs over a large area which roughly encompasses the triangle bounded by I-15, I-40, and the Nevada state line ("Desert Plants Being Removed," 1976). Specific sites within the area include: the south slope of the Providence Mountains; the Table Mountain area; near Hackberry Mountain; the area around Goffs; Cima Dome; and roadsides in Joshua Tree National Monument (Jones, 1976; Booker, 1978).

The principal items stolen are cactus and related plants. Specific species stolen include: golden cholla; yucca; medium-sized Joshua trees; prickly pear; hedgehog; ocotillo; and barrel cactus. Jones (1976) noted, from an interview with Brian Booker, that the red barrel cactus was becoming rare on the California desert as a result of plant collecting. This increasing rarity should be no surprise -- 40,000 cactus (of all types, red barrel

being most desirable) and 10,000 Joshua trees were estimated stolen in 1976 (Booker, 1978). Specifically, yuccas have been eliminated from some parts of the Table Mountain area and Joshua trees have been taken from Cima Dome.

Plant theft also takes place outside of the described triangle. One early casualty was the grizzly bear cactus (*Opuntia* ERINACEA V. URSINA *ursina*), perhaps because its distribution was relatively restricted. In 1940, Jaeger bemoaned the loss of much of its population, near Ord Mountain, to commercial "cactus hogs." Some plant theft has also taken place in the western Colorado Desert -- principally ironwood for firewood. Portions of Mesquite Dry Lake have been denuded of mesquite, sold in Nevada as barbeque wood (Booker, 1978).

E. Off-road Vehicle Damage

Another recent impact to desert vegetation is caused by off-road vehicles (ORVs). Lack of both the technology and population base prevented this activity from occurring until after World War II. Since the 1960s, however, the widespread use of desert ORVs has made the problem significant.

ORVs, by their very nature, are designed to traverse areas not intended for the average passenger car. Some off-road drivers travel only on designated trails while others prefer to create new routes. The creation of new routes, particularly when erosion or other factors have made previous ORV routes impassable, makes it appear that ORV areas are continually expanding despite BLM designations designed to control the vehicles. Dune areas where plant life is less abundant are among the favorite areas for ORV enthusiasts. However, non-dune areas around Dove Springs and Plaster City and in Jawbone Canyon, Stoddard and Johnson Valleys, the Randsburg area, and the Yuha Basin are also ORV playgrounds. Many areas near the coastal mountain ranges are also affected; most are on private land although BLM-owned Piute Butte has also been heavily used.

Damage to these areas, particularly away from the dunes, has been heavy (Sering, 1978). In addition to removing vegetation (particularly forbs), these vehicles kick topsoil into the air, effectively preventing new seedling development in many areas. On the whole, biomass is abruptly reduced in

after annual use for 10 years, and pit areas of 1/2 ha were similarly impacted. As expected, their study along the Barstow-Las Vegas race route showed that, in some cases, these sites produced a decrease in the number of live plants, an increase in dead shrubs, a decrease in canopy size per shrub, and a decrease in the diversity of plants. In a few instances, however, the hypothesis was reversed. In one case, the number and coverage size increased for *Acamptopappus sphaerocephalus*; in another, the canopy cover per shrub of *Ambrosia dumosa* increased. The number of *Schismus barbatus*, an alien forb, also increased in one of the disturbed sites (Davidson and Fox, 1974, p. 381).

F. Air Pollution Damage

Although not yet a major problem for desert plants, several instances of apparent air pollution-caused impacts have been reported. These reported impacts have taken place primarily in the Coachella Valley where air pollution is among the highest in the desert. Other sites, as yet unstudied, may also be affected.

Most of the data available on the impacts of smog on plants has been presented by McHargue (1973). Noticing that "much of the vegetation in the Coachella Valley seemed to appear diseased or lacking in vigor" when his study began, he informally monitored sites near Palm Springs, Palm Desert and Desert Hot Springs to observe possible changes. His most startling results were from near Desert Hot Springs. He concluded that much of the vegetation there was "obviously in difficulty" and that certain species were failing to reproduce. Bursage had declined precipitiously on some sites, especially on finer soils. In fact, some 0.1 ha sites had mortality rates of 90 to 95 percent. On these sites, he reported,

> the remains of many dead individuals dot the surface. Living plants appeared as if they had been burned. Leaves were curled and many were dead.

The extent of destruction appeared to correlate closely with the number of days deemed unhealthy by air pollution authorities. Therefore, vegetation improved somewhat during the last 1-1/2 years of the study when there were fewer days designated "smoggy."

Bursage was not the only species adversely affected by smog. McHargue also noted that the number of jumping cholla on the bajadas west of Palm Springs was only about 0-10 percent of that existing 20 years ago; moreover, present reproduction was not adequate to maintain the present level of plants. Other *Opuntia* species, however, appeared to be unaffected by the pollution.

Creosote appearance and reproduction were also affected at sites near Desert Hot Springs. Possible ozone damage caused the plants to appear faded and reproduction appeared to be stifled. *Krameria* species were also affected on these sites, while *Dalea fremontii* var. *minutifolia* exhibited less conclusive but still significant changes.

Laboratory examinations have confirmed the susceptibility of plants to ozone damage. In an artificial test performed by Strain and Muriel (1969) on seven desert species, bursage was again shown to be highly sensitive to ozone, as were the desert catalpa and the blue palo verde. Desert lavender, catclaw and sweetbush showed relatively little ozone damage and the jojoba plant showed none.

It must be emphasized, however, that no field-based proof exists that air pollution directly affects plant growth and distribution. Much of the evidence is circumstantial and local residents have attributed many of these effects to drought. The jumping cholla decrease may be attributed, at least in part, to plant collecting. The elimination of predators in the study area may also be a factor. More research is needed to clarify these

effects. Other high-smog sites recommended for research are along Interstate 15 south of Victorville or in the East Mesa area downwind from several heavily-polluting factories in Mexicali (McHargue, 1973, pp. 267-68).

ANNOTATED REFERENCE LIST*

Adams, Charles F., 1957, *Plants of Joshua Tree National Monument.* Globe, Arizona, Southwestern Monuments Association.

This is a short annotated flora, written by a former Monument Superintendent.

Adams, Susan, B.R. Strain, and M.S. Adams, 1970, "Water-repellant Soils, Fire, and Annual Plant Cover in A Desert Scrub Community of Southeastern California." *Ecology* 51:696-700.

This short article is not generally aimed toward vegetation description. The introductory material is helpful, however. Generally available.

Anderson, Edgar, 1952, *Plants, Man and Life.* Berkeley, University of California Press.

This is a good general work showing the importance of invading species in general, with some reference to California's annual grasses.

Aschmann, Homer, 1959, "The Evolution of A Wild Landscape and Its Persistence in Southern California," *Annals of the Association of American Geographers*, 49:34-56.

Aschmann, Homer, 1976, "Man's Impact on the Southern California Flora," *Symposium Proceedings, Plant Communities in Southern California,* June Latting, editor, California Native Plant Society, Special Publication No.2, p. 40-48.

Aschmann, Homer, 1977, "Aboriginal Use of Fire," *Proceedings of the Symposium on the Environment in Mediterranean Ecosystems,* USDA Forest Service General Technical Report WO-3, pp. 132-41.

This series of three articles gives many of the best details concerning the overall impacts of man -- particularly aboriginal man -- on California's primeval landscape. Each of the articles deals with different aspects of vegetation modification, and the 1959 article includes one of the few published statements directly addressed to the study at hand.

Axelrod, D.I., 1977 "Outline History of California Vegetation," *Terrestrial Vegetation of California,* M.G. Barbour and J. Major, editors, John Wiley and Sons, New York, p. 139-193.

This article provides a good overview of the desert as part of a statewide study.

*Additional references provided in Addendum.

Barbour, Michael G. and Jack Major, editors, 1977, *Terrestrial Vegetation in California,* New York, John Wiley and Sons.

Currently this is the best single source on California vegetation patterns. It includes little data, however on vegetation dynamics.

Bard, Robert Charles, 1973, "Settlement Pattern of the Eastern Mojave Desert," unpublished Ph.D. dissertation, University of California, Los Angeles.

This is an excellent treatise on changing land use in the eastern Mojave Desert; some comments appear on early range activities.

Baum, B.R., 1967, "Introduced and Naturalized Tamarisks in the United States and Canada *(Tamarix)*," *Baileya* 15, p. 19-25.

This is a short article classifying the tamarisks; little distribution data is given.

Beacham, R. Mitchell, 1978, Biology professor, National City, California, Personal communication, October 9.

Mr. Beacham conducted a BLM floristic study of the Western Colorado Desert. He noted few major changes, except *Tamarix* invasion in washes.

Beatley, Janice C., 1973, "Russian Thistle *(Salsola)* Species in the Western United States," *Journal of Range Management* 26:225-226.

This is a short but informative article with little definitive distribution data. Several published sources concerning this plant are neglected.

Beatley, Janice C., 1974, "Effects of Rainfall and Temperature on the Distribution and Behaviour of *Larrea tridentada* in the Mojave Desert of Nevada," *Ecology* 55:245-261.

Beatley, Janice C., 1975, "Climates and Vegetation Pattern Across the Mojave/Great Basin Desert Transition in Southern Nevada," *American Midland Naturalist* 93:53-70.

These articles report the results of studies performed over a 10-year period along the ecotone between creosote bush scrub and sagebrush scrub. Though the studies were conducted in Nevada and are highly technical, some insight is given on the relative stability of these vegtation zones.

Bell, Mr. Charles, 1978, San Bernardino County Environmental Analysis, personal communication, October 3.

Mr. Bell has traveled many miles observing desert plant life in his job with San Bernardino County.

Benson, Lyman, 1941, "The Mesquites and Screwbeans of the United States," *American Journal of Botany* 28:748-754.

This is one of several articles on the *Prosopis* genus; it is not generally directed at California because of the plants' limited distribution here.

Blake, William P., 1856, "Geological Report," Part II of *Reports of Exploration and Surveys to Ascertain the Most Practicable and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean,* Vol. 5, Washington, Beverley Tucker Printing.

Blake was the first scientist to traverse many portions of today's Imperial and Coachella Valleys. A geologist by profession, he also directed his efforts to botany, but on a more limited scale.

Booher, Brian, 1978, Director, California Desert Rangers, Bureau of Land Management, Riverside, personal interview, September 13.

Because of Mr. Booher's occupation, he has become the leading authority on plant theft in the California deserts.

Bowser, Curtis, 1957, "Introduction and Spread of the Undesirable Tamarisks in the Pacific Southwestern Section of the United States," Abstract in *American Geophysical Union Transactions* 38:415-416.

This article contains a valuable though brief summary of tamarisk origins and distribution.

Bradley, W. Glen, 1970, "The Vegetation of Saratoga Springs, Death Valley National Monument," *Southwest Naturalist* 15:111-129.

A flora is included with this article.

Brewer, William H, 1966, *Up and Down California in 1860-1864,* revised edition, edited by Francis P. Farquhar, Berkeley, University of California Press.

Brewer has written a good early account of general conditions in California; deserts are covered peripherally.

Bryan, Kirk, 1925, "Date of Channel Trenching (Arroyo Cutting) in the Arid Southwest," *Science* (n.s.) 62:338-344.

This article helps to explain the date of arroyo cuttings, which caused great vegetation changes. The CDCA (Alamo and New Rivers, specifically) is mentioned only incidentally.

Burcham, Levi T., 1957, *California Range Land; An Historico - Ecological Study of the Range Resource in California,* Sacramento, California Department of Natural Resources, Division of Forestry.

This is the source which best details the history of range destruction and species change in California. He focuses on Oak Woodland and California Prairie areas as areas of greatest change, ignoring deserts almost entirely because of their lack of economic importance.

Carrico, Richard L., 1978, Anthropological consultant, WESTEC Services, Inc., personal interview, October 4.

Mr. Carrico was co-author of the historical land use study of the CDCA, and is a practicing archeologist knowledgeable about many Southern California areas.

Casebier, Dennis, 1975, *The Mojave Road.* Norco, California, Tales of the Mojave Road Publishing Company.

Casebier, Dennis, 1976, *The Mojave Road in Newspapers.* Norco California, Tales of the Mojave Road Publishing Co.

Mr. Casebier's thorough research provides a plethora of data on a route which is otherwise little known. His books compile many original accounts of early desert treks, which invariably include information on vegetation both at spring sites and along the trail.

Clarke, Charlotte, 1977, *Edible and Useful Plants of California.* Berkeley, University of California Press.

This book has some comments on plant pirating.

Clarke, Oscar, 1978, Herbarium curator, University of California, Riverside, personal interview, September 29.

Mr. Clarke's long field experience and particular interest in major invading desert grasses have made him an authority on desert plant life.

Clements, Frederic E., 1934, The Relict Method in Dynamic Ecology," *Journal of Ecology* 22:39-68.

Clements, Frederic E., 1936, "The Origin of the Desert Climax and Climate," in *Essays in Geobotony*, T.H. Goodspeed, Berkeley, University cf California Press.

Clements appears to be the only academician to stress the dynamics of vegetation in California. Both articles concentrate on all areas of California and discuss the ramifications of climate and other factors on the evolution and distribution of plant life.

Colling, Ralph, 1978, Realty specialist, Bureau of Land Management, Riverside, personal interview, September 13.

Mr. Colling has contributed many specific comments concerning observed vegetation modification in the Califonia desert.

Cooper, Charles F., 1961, "The Ecology of Fire," *Scientific American* 204:150-160.

This article is not generally concerned with desert areas; however, the lack of emphasis placed upon deserts is itself significant.

Crampton, Beecher, 1974, *Grasses in California*, Berkeley, University of California.

This is a flora of California grasses with many examples of introduced species and their distributions.

Croizat, Leon, 1952, *Manual of Phytogeography, or An Account of Plant Dispersal Throughtout the World*, The Hague, Uitgeverij, Dr. W. Junk.

This is a general account on palobotany and related fields, with some discussion of the California fan palm.

Davidson, Eric and Martha Fox, 1974, "Effects of Off-Road Motorcycle Activity on Mojave Desert Vegetation and Soil," *Madrono* 22:381-390.

This study is concerned with the vegetation and soil impacts of ORV traffic, both at the starting areas and at selected pits and raceways along the Barstow-Las Vegas race course.

Davy, Joseph Burtt, 1902, *The Native Vegetation and Crops of the Colorado Delta in the Salton Basin*, supplement to Department of Agriculture Bulletin 140, Sacramento, California State Printing Office.

A timely article on the vegetation of the Imperial Valley before the 1905-07 flood; generally and principally related to potential agricultural usage.

Dean, Leslie E., 1978, "The California Desert Sand Dunes," University of California Riverside, Department of Earth Science.

A statistical overview of the 18 dune systems in the CDCA performed as a combined BLM-National Aeronautics and Space Administration project. A few moving dune systems, affecting plant growth on both sides of the dunes, are explained.

Dedecker, Mrs. Mary, 1978, Amateur botanist, Independence, California, personal communication, October 2.

Mrs. Dedecker is both a botanist and inveterate traveler in the northern CDCA.

Edwards, E.I., 1969, *The Enduring Desert*, Los Angeles, Westernlore Press.

Mr. Edwards is an authority on desert source material. *The Enduring Desert* is an annotated account which is valuable both for its wide coverage of little-known materials and for the author's annotated commentary.

Emory, Colonel William H., 1848, *Notes of A Military Reconnaissance, from Fort Leavenworth, in Missouri, to San Diego, in California Including Part of the Arkansas, Del Norte and Gila Rivers*, Washington, Senate Executive Document 7.

Emory was one of the first to write about the deserts, and the first Anglo to describe the trek along the Southern Route. His party first described the fan palm, calling them "cabbage trees."

Ernst, Paul, 1977 *"Discussion of Fluctuations in Rangeland Use On the California Desert,"* Riverside, California, Bureau of Land Management, unpublished report.

Prepared by a BLM employee, this report covers almost entirely new material and is the result of much primary research. Most of his material was gained through interviews with ranchers and other desert old-timers.

Flock, Dr. William, 1978, Agricultural commissioner, State of California, El Centro, California, personal communication, October 2.

Dr. Flock has suggested several weedy species which had been recently observed as escapes from the Imperial Valley.

"The Eucalypts," 1902, *Forestry and Irrigation*, 8:511-515.

A fanciful report, doubtless prepared by the magazine's editor. It makes the serious suggestion that many of our semi-desert, barren hillsides be beautified and economically enriched through eucalyptus plantings.

Frankel, Robert E., 1970, *Ruderal Vegetation Along Some California Roadsides*, Berkeley, University of California Press.

A publication developed at California's desert areas, however, both roadside theory and a study site similarly vegetated with those in the CDCA make this contribution worthwhile.

Gallegos, Dennis, 1978, Desert archaeologist, WESTEC Services, Inc.. Personal interview, October 20.

Mr. Gallegos is a former BLM archeologist, and has noted many sites impacted by lumbering, fires and other uses.

Grinnell, Joseph, 1914, "An Account of the Mammals and Birds of the Lower Colorado Valley," *University of California Publications in Zoology* 12:1-89.

The introductory chapter in this monograph describes in some detail the vegetation in the Colorado River Valley.

Harter, Edmund Cecil, 1912, *"Iron-Ore Deposits of the Eagle Mountains, California."* United States Government Survey Bulletin 503, Washington, Government Printing Office.

This work includes a short vegetation description along with several photographs taken about 1900.

Hastings, James R., and Raymond Turner, 1965, *The Changing Mile*, Tucson, University of Arizona Press.

This is seminal work in the field of vegetation change in the Southwest. The study area, however, is restricted to Arizona. This report documents, principally through use of paired photographs, the deterioration of Arizona's grasslands, particularly by mesquite invasions.

Henderson, Randall, 1951, "Wild Palms of the California Desert," *Desert* 14:132.

The popular authority on palm groves in the CDCA, Henderson has written many articles on individual palm groves in *Desert*, the magazine which he co-founded and edited for many years.

Humphrey, Robert F., 1958, *The Desert Grassland*, Tucson, University of Arizona Press.

Like *The Changing Mile*, this is a popular work on changing vegetation conditions (also restricted to Arizona).

Hunt, Charles B., 1966, *Plant Ecology of Death Valley*, United States Geological Survey Professional Paper No. 509, Washington, Goverment Printing Office.

This is a very thorough analysis of vegetation conditions in Death Valley. Hunt noted numerous examples of vegetation change, many from personal observation.

Jaeger, Edmund C., 1938, *The California Deserts*, Revised printing, Stanford, California, Stanford University Press.

A good all-around handbook for all aspects of the California desert. It shows several instances of vegetation modification.

Jaeger, Edmund C., 1940, *Desert Wildflowers*, Stanford, California, Stanford University Press.

As described in the introduction of this report, Jaeger's work is an excellent, non-technical, fully informative botanical guide, with many descriptions of vegetation change and cultural modification.

Jaeger, Edmund C., 1956, "Plant of the Month," *Desert* 19 (June), p. 21.

Dr. Jaeger wrote this column for *Desert Magazine* for several years.

Jepson, Willis Lynn, 1923, *The Trees of California*, 2nd edition. Berkeley, Sather Gate Bookshop.

This work is not particularly concerned with the desert, but there are some notes concerning pioneer use of trees.

Johnson, David H., Monroe D. Bryant and Alden H. Miller, 1948, "Vertebrate Animals of the Providence Mountains of California," *University of California Publications in Zoology*, Vol. 48, No. 5.

A good vegetative description precedes the zoological coverage. The authors found no evidence of vegetation change in their study area.

Johnson, Hyrum B., Frank C. Vasek, and Terry Yonkers, 1975, *Productivity, Diversity and Stability Relations in Mojave Desert Roadside Vegetation*, Bulletin Torrey Botanical Club, 102:106-115.

The authors provide an analysis, through the scrutiny of several small study sites, of the effect of roadsides in changing the local vegetation.

Johnson, Hyrum B., 1976, Vegetation and Plant Communities of Southern California Deserts -- A Functional View, *Symposium Proceedings, Plant Communities of Southern California*, edited by June Latting, California Native Plant Society, Special Publication No. 2, pp. 125-164.

Primarily a methodological essay on desert classification systems, this work provides an excellent discussion of causative factors behind vegetation type determination. However, it is only marginally related to vegetation change.

Jones, Robert A., 1976, "Wholesale Plant Thefts Imperial Desert Environment," *Los Angeles Times*, December 19, II:1.

Like an earlier *Los Angeles Times* article, this is an expository story on plant theft; it is more complete than the earlier article.

King, Thomas Jackson, Jr., 1976, "Late Pleistocene-Early Holocene History of Coniferous Woodlands in the Lucerne Valley Region, Mohave Desert, California, " *Great Basin Naturalist* 36:227-238.

This work provides examples of vegetation that existed in earlier geologic periods.

Lippincott, J.B., 1902, "Irrigation Possibilities of the Lower Colorado River," *Forestry and Irrigation* 8:15-159.

This article briefly discusses the vegetation along the Colorado River. However, its utility is limited because the vegetation was discussed only in relation to future economic productivity.

Los Angeles Times, 1976, "Desert Plants Removed, Sold in Arizona," December 3, I-3.

An expository article describing the extent of plant stealing in the CDCA, chiefly between Interstate Highways 15 and 40.

Lowe, Gary, 1978, Geological-biological consultant, WESTEC Services, Inc., personal interview, October 2.

Mr. Lowe provided geological and paleobotanical expertise, and described several site-specific examples of vegetative alteration.

Marks, John Brady, 1950, "Vegetation and Soil Relations in the Colorado Desert," *Ecology* 31:176-193.

Although vegetative change data are not stressed in this article, there are comments on invasions of tamarisk and other plants.

McHargue, Lawrence Thomas, 1973, *A Vegetational Analysis of the Coachella Valley, California*, unpublished Ph.D. dissertatio, University of California, Irvine.

This dissertation is an excellent, thorough look at Coachella Valley vegetation, its recent changes and its current status. Flood and air-pollution damage are especially well covered.

Mitchell, Richard S., 1973, "Phytogeography and Comparative Floristics," in Robert M. Lloyd and Richard S. Mitchell's, *Flora of the White Mountains of California and Nevada* Berkeley, University of California Press.

Mitchell gives a particularly valuable discussion of the paleobotany of the region, and gives several examples of species introduced to the desert during recent geologic times.

Munz, Philip A., 1935, *A Manual of Southern California Botany*, San Francisco, J.W. Stacey.

Several species introduced to the desert are noted in this major work. However, distributional data is not specific enough to provide effective comparisons for this study.

Munz, Philip A., 1974, *A Flora of Southern California*. Berkeley, University of California Press.

Though several botanists suggest that this book is poorly organized, it does contain a great deal of useful data. Like the previous work, plant distributions are often exceedingly general. A cross-reference of both current and outdated scientific names located in the back of the book is helpful for indexing purposes.

Murphy, Robert H., 1972, *Wildrose Charcoal Kilns*, Death Valley, Death Valley '49ers, Inc.

This interesting pamphlet describes the lumbering operations involved in the kiln and smelter operations of a century ago.

Norris, Frank and Richard L. Carrico, 1978, *A History of Land Use in the California Desert*. San Diego, WESTEC Services, Inc.

A general overview of all major land-use activities in the CDCA, it was written for a BLM contract.

Parish, Samuel B., 1914, "Plant Ecology and Floristics of the Salton Sink," in D.T. McDougal *et al., Salton Sea: A Study of the Geography, Geology the Floristics and the Ecology of a Desert Basin*, Washington, Carnegie Institute, pp. 85-114.

This remarkable work includes a comprehensive flora of the Salton Sink area, along with text and pictures that show many small-scale ecological changes along the Salton Sea shoreline.

Parish, Samuel B., 1930, "Vegetation of the Mohave and Colorado Deserts of Southern California," *Ecology* 11:481-499.

This is a general account of desert vegetation. Little data is included on vegetation dynamics.

Priggy, Barry, 1978, Graduate student, Rancho Santa Ana Botanic Garden, personal communication, October 3.

Mr. Priggy has gained an extensive knowledge of desert plant life, principally through several floristic studies that have been conducted through the Garden.

Quincey, Sam Robert, 1960, *The Distribution and Aspects of Plant Communities in a Portion of the Vallecito Area, Southern California*, unpublished M.A. thesis, University of California, Los Angeles.

This thesis is too small in its study area to be generally helpful, but a few introduced species are noted.

Robbins, W.W., 1940, *Alien Plants Growing Without Cultivation in California*, University of California, Agricultural Experiment Station Bulletin 637. Berkeley, University of California Press.

This is a valuable worthwhile article on invading species. Mr. Robbins has consulted over a hundred separate floras (some of which deal with the desert) to describe the existence and progress of many alien species.

Robbins, W.W., Margaret Bellue and Walter S. Ball, 1941, *Weeds of California*. Sacramento, California Superintendent of Documents.

This work is less academically detailed, and, therefore, less helpful work than that published by Robbins a year previously.

Robinson, T.W., 1965, *Introduction, Spread and Areal Extent of Saltcedar (Tamarix) in the Western United States*, United States Geological Survey Professional Paper 491-A.

This is, perhaps, the best overall treatment of the problem of tamarisk invasion, supplemented by a detailed (though small-scale) distribution map.

Roosma, Aino, 1958, "A Climatic Record from Searles Lake, California," *Science* (n.s.) 128:716.

This article provides paleobotanical data from one Mojave Desert location.

Sering, John, 1978, Wilderness Planner, Bureau of Land Management, Riverside, California, personal communication, October 3.

Mr. Sering has traveled extensively in the CDCA, particularly this year during the wilderness inventory, and has observed many of the more obvious vegetation alterations.

Settle, Glen A., (compiled by), 1973, *Here Roamed the Antelope*, Rosamond, California, Kern-Antelope Historical Society.

This publication is a helpful guide to Antelope Valley history, providing details of grazing conditions, agricultural development, and other activities.

Spears, John R., 1892, *Illustrated Sketches of Death Valley and Other Borax Deserts of the Pacific Coast*, Chicago, Rand McNally and Company.

One of the first to write accurately about Death Valley, Spears noted few vegetation changes.

Stones, Alan Gale, 1964, *Antelope Valley, Mojave Desert, California; A Geographic Analysis*, unpublished M.A. thesis, University of California, Los Angeles.

This M.A. thesis provides a general overview of the Antelope Valley, and notes only a few vegetation changes.

Strain, B.R. and J.F. Muriel, 1969, *Effects of Air Pollutants on Vegetation in the United States*, manuscript, 21 pp.

Not consulted by the author (gleaned from McHargue's Ph.D. dissertation), this work is included because it contains data linking smog exposure to deterioration of desert plants under laboratory conditions.

Thompson, David G., 1929, *Mohave Desert Region, California; A Geographic, Geologic and Hydrologic Reconnaissance*, Washington, United States Geological Survey Water-Supply Paper 578.

A comprehensive study of the Mojave Desert, concentrating on its hydrology. Grazing history and grazing potentials are occasionally included.

Thorne, Robert F., 1978, Botanist, Rancho Santa Ana Botanic Garden, Claremont, California, personal interview, October 16.

An on-site observer of desert plant life for many years, Thorne is especially familiar with the Kingston, Providence, New York, Clark and Granite Mountains.

United States Department of the Interior, various dates, 1855-1941, Land Survey Records, Bureau of Land Management, various townships.

Listed in Appendix 2, these notes contain valuable vegetation notes available from no other source. Conclusions regarding grass deterioration, species invasion and other vegetation changes can therefore be made. However, care should be taken regarding those conclusions, because technological changes, the varying expertise of surveyors and other factors make absolute comparison impossible.

Vasek, Frank C., 1978, Botany professor, University of California, Riverside, personal interview, September 22.

Dr. Vasek provides information on sites of species invasions and highway vegetation modification. In addition, he suggested several excellent research sources some of which have been incorporated into this report.

Vasek, Frank C., Hyrum B. Johnson and Dave Eslinger, 1975, "Effects of Pipeline Construction on Creosote Bush Scrub Vegetation ofthe Mojave Desert," *Madrono* 23:1-13.

This study investigates the phenomenon of succession on disturbed Mojave Desert sites. It scrutinizes regrowth rates and species counts on those sites and suggests some conclusions generally applicable to distrubed sites on desert bajada slopes.

Vogl, Richard J. and Lawrence T. McHargue, 1966, Vegetation of the Fan Palm Oases on the San Andreas Fault *Ecology* 47:532-540.

The peculiar problems of the delicate but highly-visited popular fan-palm oases are discussed in this article. Little definitive data is given, however, on species invasion or diminishment.

Warren, Elizath Von Till, and Ralph J. Roske, 1978, *Cultural Resources of the California Desert, 1776-1880: Historic Trails and Wagon Roads*, Bureau of Land Management, Desert Planning Unit, Riverside, California.

This report provides a good overview of information sources available on desert trails. However, most of these sources do not contain data on trailside vegetation; those that do are difficult to locate in either local or regional libraries.

Weaver, E., and F.E. Clements, 1938, *Plant Ecology*, Second edition New York and London, McGray-Hill Book Company.

This book is a general overview of plant ecology, providing overall theory, but little specific data is provided on the California desert.

Wells, Philip V., 1961, "Succession in Desert Vegetation on Streets of a Nevada Ghost Town," *Science* 134:670-71.

This study gives data on regrowth rates and plant/species in a desert ghost town, a rarely-available desert site. The town, virtually untrod upon since it was vacated, provided an excellent opportunity to study desert succession.

Wells, Philip V. and Rainer Berger, 1967, "Late Pleistocene History of Coniferous Woodland in the Mohave Desert," *Science* 155: 1640-47.

Provides paleobotanical data on several Mojave Desert sites.

WESTEC Services, Inc., 1977, *Survey of Sensitive Plants of the Algodones Dunes*, prepared for the Department of the Interior, Bureau of Land Management, Riverside, California.

A flora of introduced species in the dunes area is provided in the appendix of this work.

Wilson, Ruth, 1978, Biology Professor, San Bernardino State College, personal communication, October 13.

Dr. Wilson compiled a flora of the western Mojave Desert for the BLM, and noted several vegetation alterations.

Woodward, Susan Lee, 1976, *Feral Burros of the Chemehuevi Mountains, California; The Biogeography of a Feral Exotic*, unpublished Ph.D. dissertation, University of California, Los Angeles.

This dissertation combines, in one paper, most of the available data concerning burro impacts in the California desert. However, the specific study area occupies only one area where burros are concentrated. Woodward's conclusions appear well-reasoned and scientific, unlike previous authors, and appear applicable to expected impacts in other desert ranges.

ANNOTATED REFERENCE LIST
ADDENDUM

Bolton, Herbert Eugene, 1927, *Friar Juan Crespi: Missionary Explorer on the Pacific Coast, 1769-1774*, Berkeley, University of California Press.

Dr. Bolton presents a translation and narrative of the writings and early travels of one of the most perceptive Spanish missionaries and explorers. Crespi's descriptions of 18th century California include geographic information, botanical notes and insights into native American life on the dawn of Spanish domination. Bolton's footnotes enhance the text and clarify several otherwise ambiguous passages.

Castetter, Edward F., and Willis H. Bell, 1951, *Yuman Indian Agriculture: Primitive Subsistence of the Lower Colorado and Gila Rivers*, Albuquerque, University of New Mexico Press.

In their now-classic study of agriculture among the Yuman-speaking Indians of the Lower Colorado and Gila Rivers, Castetter and Bell have provided a seminal ethnographic/ethnohistoric work. The background research is exceptionally thorough, the synthesis of data is a major contribution to Indian agricultural history and the bibliography will provide the reader with a wide variety of important and cogent references.

Evans, Col. Albert S., 1873, *A la California: Sketches of Life in the Golden State*, San Francisco, A.L. Bancroft and Company.

The narratives provided by Col. Evans in this original printing of his travelogues offer a unique glimpse into late 19th century life in California. Evans was a knowledgable observer of natural features, local customs and Indian life. Frequently overlooked by researchers, Evans' colorful descriptions should not be missed.

Lewis, Henry T., 1973, *Patterns of Indian Burning in California: Ecology and Ethnohistory*, Ramona, Ballena Press.

The introductory article to this well-researched documentation of Indian manipulation of nature through burning is by Dr. Lowell John Bean and Harry W. Lawton. The presentation of ethnohistoric and ethnographic data verifying extensive and successful native burning is long overdue and valuable. Dr. Bean and Lawton offer a logical, well-referenced discussion of ecological management through firing. Those who still perceive the California Indians as simple foragers would do well to read this monograph.

Simpson, Lesley Bryd, (translated by), 1938, *California in 1792: the Expedition of José Longinos Martínez*, San Marino, California, The Huntington Library.

In her translation of the diary of Spanish explorer José Longinos Martínez, the author has made a significant document available to the general English-speaking audience. Simpson's translation provides a wealth of firsthand descriptions of northern Baja California and southern Alta California. José Martínez was an intrepid explorer and thorough chronicler of geography, botany and aboriginal lifeways.

Tibesar, Antonine (editor), 1955, *Writings of Junipero Serra*, Volume 1, Washington, Academy of American Franciscan History.

This multi-volume series affords an opportunity to read documents, letters and *informes* written by the single most influential missionary in Spanish California. The reader seeking to understand the zealous nature of this founding priest will do well to read these volumes. Historians and ethnohistorians will find Serra's reflections on aboriginal life informative, although ethnocentric.

APPENDIX A

DYNAMIC CALIFORNIA DESERT FLORA

The plants listed on the following pages are those whose distribution in the California desert is known to have been affected by man. These plants are either: 1) invading species; 2) major pioneer plants; 3) species that take advantage of man's specialized habitats -- towns and gardens, canal banks or reservoirs, roadsides, abandoned or irrigated fields. Those species that have been mentioned as altered in the text are not generally described here.

The order of species, and all scientific nomenclature are according to Munz, 1974; distribution and habitat data are those of Munz unless otherwise stated.

In the "distribution/source/date" column, the following abbreviations are used:

Geographical Locations:

Alg. = Algodones
Ant. = Antelope
Colo. = Colorado
Cch. = Coachella
Imp. = Imperial
L.A. = Los Angeles
P.V. = Palo Verde
Riv. = Riverside

c. = central
n. = north
w. = west

Co. = County
D. = Desert
Mtns. = Mountains
V. = Valley
S.B. = San Bernardino
S.D. = San Diego
Son. = Sonoran
JTNM = Joshua Tree National Monument
e. = east
s. = south

Vegetation Types:

AS = Alkali sink
CBS = Creosote bush scrub
CRV = Colorado River Valley
JTW = Joshua Tree Woodland
PJW = Pinyon-Juniper Woodland
SS = Sagebrush scrub

Abundance:

W - waif
A - adventive
R - rare
O - occasional
C - common
F - frequent

Other Abbreviations:

des. - desert(s)
elev. - elevation
hwys. - highways
introd. - introduced
natur. - naturalized
nr. - near
regs. - regions

Source Materials are indicated by numbers as listed below. Complete references are included within the reference section of the main report.

(1) - Parish, 1914
(2) - Robbins, 1940
(3) - Jaeger, 1940
(4) - WESTEC, 1977
(5) - Adams, 1957
(6) - Wilson, 1978
(7) - Flock, 1978
(8) - Bellue, 1936
(9) - Hunt, 1966
(10) - Thompson, 1929
(11) - Vasek, 1978
(12) - Woodward, 1976

Scientific name (common name)	Country of origin	Habitat(s): undisturbed	irrig. flds.	ab'd fields	roadsides	gdns/towns	canalbanks	Distribution/ source/date
Mollugo cerviana	Old World	x						CBS,JTW-O
Amaranthus blitoides	Trop. Am.		x			x		Mecca-R(1);Panamint Mtns. 1891,Lancaster 1897,Victorville 1913, Adelanto,Palm Springs 1920s(2)
Amaranthus californicus	Native?	x				x		Imp.V.-C,Ft.Yuma-C(1); Cch.V.
Amaranthus palmeri	Native	x				x		weed,desert valleys, CBS
Amaranthus spinosus	Old World	?				?		Ant.V.-O
Ambrosia acanthocarpa	Native	x			x			Colo.,Moj.D.(3);"distributed by human agencies"
Ambrosia psilostachya var. californica	Native			x	x			Imperial-A(1);Colo. D.-C
Anthemis cotula	Europe		?			?		Imp.V.-A(1)
Artemisia biennis	n.w.U.S.or Europe				x	x		Victorville,1915(2); Oro Grande-O
Artemisia douglasiana	Native					x		Victorville
Artemisia dracunculus	Native			?	?	?		JTW
Aster elixis, var. Australis	?		x			x		Salton Sink,CRV(1); [not in Munz]
Aster spinosus	Native	x	x		x		x	(3);AS,CBS,CRV. "troublesome weed"
Baileya pleniradiata	Native	x			x			Colo.,Moj.D.-C(3)
Bidens expansa	?					x		Mecca-R(1);[not in Munz]
Bidens frondosa	Eurasia					x		Victorville-O
Bidens pilosa	Trop. Am.				x			Mecca-W(1);s.Cal.weed
Carduus nutans	Europe				?			Victorville-O
Carthamus tinctorus	e.,s.Medit.	?						Ant.V.,1929-O(2)
Centaurea repens	Caucasus Mtns.		x		x		x	Imp.Co,widely natur.; 1st arrived 1910(2)
Conyza canadensis	Native?		x			x		Salton Sink-C(1)
Cotula coronopifolia	S. Africa						x	desert edge-C

Scientific name (common name)	Country of origin	Habitat(s): undisturbed	irrig. flds.	ab'd fields	roadsides	gdns/towns	canalbanks	Distribution/ source/date
Eclipta alba	e.U.S. or Trop. Am.		x			x	x	Ft.Yuma-C,Imp.V.-C. (1);Alg.Dunes canals (4)
Filago arizonica	Native				?	?		CBS-O
Geraea canescens	Native	x			x			roadsides,both des. (3)
Gnaphalium chilense	Native					x		desert-O
Grindelia squarrosa	Grt.Plains			x		x		JTW;Ant.V.,w.Moj.D-O
Gutierrezia microcephala	Native	x		x		x		homesteads,Moj.D, Inyo Co.,Little S.B. Mtns.(3)
Helenium puberulum	Native		?			?		Victorville
Helianthus annuus	Native?		x			x		Imp.V.-O,Mecca-R(1); JTNM,brought in by visitors(5)
Heterotheca grandiflora	Native?				x			nr.Calexico-A(1)
Lactuca serriola	Europe	x					x	Alg.Dunes canal banks -O(4);on the deserts -C
Lessingia lemmonii, var. peirsonii	Native	x			x			roadsides,lower Owens V.(3)
Malacathrix clevelandii	Native	x			x			roadsides,both des. (3)
Sonchus asper	Europe		x					Imp.V.-O(1);des.-O
Sonchus oleraceous	Europe		x			?		Imp.V.-C(1)
Viguiera multiflora var. nevadensis	Native	x	?					in cultivation-O(3)
Xanthium commune	?		?					Imp.V.-C(1);[not in Munz],Mecca-R(1)
Cryptantha angustifolia	Native	x			x			roadsides, both des. (3)
Heliotropum curissavicum var. oculatum	Native	x					x	Imp.V.(3)(not in Munz]
Amsinckia tessellata	Native			x				Ant.V.(6);CBS,JTW,SS
Brassica tournefornii	N.Africa	x	x		x			Colo.D.(7);Imp.Co.
Brassica arvensis	Europe					x		Coachella,1935-O(2)

Scientific name (common name)	Country of origin	undisturbed	irrig. flds.	ab'd fields	roadsides	gdns/towns	canalbanks	Distribution/ source/date
Camelina sativa	Old World	?	?		?			Little S.B.Mtns,1935 (2)
Conringia orientalis	Eurasia					x		w.of Yuma-O
Descurainia sophia	Europe	x		?				nr.Mojave(1933),Darwin(1935),Ant.V. (1937)(2)
Eruca sativa	Europe		x			x		Imp.V.-C(8)
Lepidium perfiolatum	Europe		?			?		Ant.V.-O,Redman(L.A. Co.)-1917(2)
Rorippa nasturtium-aquaticum	Europe						x	both deserts
Sisymbrium altissimum	Europe				x	x		C throughout Calif., especially Moj.D.
Sisymbrium irio	Europe		x			x		CBS nr.Alg.Dunes(4)
Silene antirrhina	Native			?				weed;open sandy places after burns
Vaccaria vulgaris	Europe	x						Baxter(S.B.Co.),1915 (2);[not in Munz]
Cleome glutea	Native	x			x			roadside plant(3)
Atriplex hortensis	Asia	?				?		"on desert"(2);[not in Munz]
Atriplex hymenelytra	Native	x			x			Death V.pioneer(9)
Atriplex rosea	Native	x			x			roadside plant(3)
Atriplex semi-baccata	Australia				x	x		Imp.V.(1);Imperial, 1935(2)
Agrostema githago	?				x			Imp.V.-W(1);not in Munz]
Bassia hyssopifolia	Eurasia/ Argentina?	?	?					Bishop-Lancaster, Imp.V.,Cch.V.,P.V.V. (2)
Chenopodium album	Europe		x	x		x		Mecca-R(1);C below 6000 feet
Chenopodium murale	Europe				x	x		Mecca,Brawley-O(1); roads nr.Alg.Dunes (4)
Chorispernum hyssopifolium	Eurasia	x						Marble Cyn.,Inyo Co.
Hologeton glomeratus	Native		?	?	?	?	?	SS,JTW;S.B.Co.

Scientific name (common name)	Country of origin	undisturbed	irrig. flds.	ab'd fields	roadsides	gdns/towns	canalbanks	Distribution/ source/date
Salsola iberica	Eurasia	x	x	x	x	x	x	details in text
Salsola paulsenii	Eurasia	x	x	x	x	x	x	details in text
Cuscuta californica	Native?					x		Holtville,Imp.V.-O (1)
Ipomoea hirsutula	Trop. Am.		x					P.V.V.,1938(2);[not in Munz]
Citrullus lanatus var. citroides	Africa		x					Imp.V.asparagus flds
Citrullus melo, var. dudaim	Africa		x					w.of El Centro, asparagus fields
Elaeagnus angustifolia	Europe	x						wet places, S.B. and Inyo Co.
Eremocarpus setigera	Native	x	x	?	x			Randsburg,Victorville (3)
Euphorbia vallis-mortae	Native	x			x			Death V. pioneer(9)
Alhagi camelorum	Asia Minor		x					Mecca 1915,Brawley 1920(2);low hot places, Colo.D. and Afton Cyn.
Lupinus sparsifolia var. Arizonicus	Native				x			Colo.D.roadsides(3)
Melilotus albus	Eurasia						x	Algodones dunes(4)
Melilotus indica	Eurasia		?			?		Imperial-A(1)
Melilotus officinalis	Eurasia		?	?	?	?	?	Death V.1935(2)
Parkinsonia aculeata	Arizona		?			?		"becoming natur."
Sesbania exaltata	Native?				x		x	nr.Imperial-O(1);Imp. Co.(3);Imp.&e.Riv.Co -F
Erodium cicutarium	Medit.area		x	x		?		Mecca(1);principal invader of abandoned fields,Moj.D.(2)
Emmenanthe penduliflora	Native		?	?	?	?	?	C after burns or disturbance,CBS,Inyo Co.
Mentha citrata	Europe	x	?			x		Mecca(1)
Salvia carduacea	Cal. coast	x						"invades desert areas from west"(3)
Salvia columbariae, var. columbariae	Native	x		x				open disturbed areas, CBS

Habitat(s)

Scientific name (common name)	Country of origin	undisturbed	irrig. flds.	ab'd fields	roadsides	gdns/towns	canalbanks	Distribution/ source/date
Mentzelia californica	Native				x			CBS, throughout n.Moj D.
Mentzelia involucrata	Native				x			CBS, Moj.&Colo.D.
Mentzelia mojavensis	Native				x			CBS, w.margin of Moj. D.in L.A.&Kern Co.
Mentzelia nitens	Native				x			CBS, SS; s.Inyo Co.
Mentzelia obscura	Native	x			x			CBS, JTW; Moj.&Son.D.
Mentzelia ravenii	Native				x			CBS, des.margins in L.A.&Riv.Co.
Mentzelia tricuspis	Native				x			CBS, c.&w.Moj.D., CRV
Mentzelia veatchiana	Native				x			CBS, JTW below 3500'
Petalonyx nitidus	Native				x			CBS, JTW, PJW; Inyo& S.B.Co.
Lythrum californicum	Native?					x		Figtree John Spring-W(1)
Hibiscus trionum	c.Africa					x		Imp.Co.-O
Horsfordia alata	Native?	x						"probably a migrant from Baja Cal. or Sonora"(3)
Malva parviflora	Eurasia					x		Salton Sink-A(1)
Sphaeralcea emoryi ssp. variabilis	Native				x			CBS; s.Moj.D.&n.Colo. D.
Ibicella louisianica	c.US	x						nr.Palm Springs(3); [not in Munz)
Ibicella parviflora	Cal.coast	x						intro'd to Death V. about 1860(3)
Boerhaavia coccinea	Native	x			x			CBS; Colo.D.
Plantago lanceolata	Europe	?	x			x		El Centro-O(1); possible escape(to margins of Imp.V.)(7)
Ipomopsis depressa	Native	x		?		?		CBS, JTW, SS; Rabbit Spr. to Owens V.
Eriogonum brachypodum	Native	x			x			CBS, PJW; along hwys(3)
Eriogonum deflexum, var. deflexum	Native	x			x			entire CDCA, along hwys.(3)
Eriogonum ordii	Native	x		x				CBS, JTW; w.Colo.D.

Habitat(s)

Scientific name (common name)	Country of origin	undisturbed	irrig. flds.	ab'd fields	roadsides	gdns/towns	canalbanks	Distribution/ source/date
Eriogonum trichopes	Native	x		x				CBS,JTW;"gives many ab'd tracts a characteristic red color" (10,p.47)
Polygonum argocolean	Asia		x					intro'd into Imp.V. 1901,spread 1920s(2)
Polygonum lapathifolium	Eurasia						x	Signal Mt.-O(1)
Rumex crispus	Eurasia					x		Mecca-A(1);low des. places-O
Portulaca oleracea	Europe					x		Mecca,Brawley-R(1)
Oligomeris linifolia	? (not native)	x						CBS,AS;margin of Imp.V.(7)
Galium aparine	Europe?		?				?	deserts-O
Ruta chalpensis	N.Africa	?		?		?		Kingston,about 1920 (2)
Populus macdougalii	s.w.US?		x			x	x	Salton Sink(1);CBS, CRV.Intro'd by SPRR (3,p.190)
Antirrhinum coulterianum	Native	x		?				disturbed and burned areas,JTNM
Mimulus fremontii	Cal.coast			x	?	x		Hesperia(3);dry,disturbed areas
Datura discolor	Native?		x		x	x	x	Salton Sink-O(1);irrig.areas(3);CBS, Colo.D.
Datura metelloides	Cal.coast	x			x			an invader along roads(3)
Nicotiana attenuata	Native		?	?	?	?	?	disturbed places; deserts-O
Nicotiana glauca	S.America				?	x		Mecca,Calexico-A(1); waste places-C
Physalis acutifolia	Native		x		x	x		Colo. D. weed
Physalis angulata var. lanceifolia	Native		x					Imp.Co.weed
Physalis pubescens var. grisea	s.e.US					x		Needles,Ft.Yuma(3); Needles weed
Solanum eleagnifolium	c.US-Mex.				x	x		Salton Sink-O(1); Needles weed

Habitat(s)

Scientific name (common name)	Country of origin	undisturbed	irrig. flds.	ab'd fields	roadsides	gdns/towns	canalbanks	Distribution/ source/date
Solanum nigrum	Europe						x	Darwin Falls-R
Tamarix chinensis	e.Asia	x			x	x	x	see text
Tamarix pallasii	?						x	Travertine Terraces-R(1)[not in Munz]
Tamarix parviflora	e.Medit.	x				x	x	see text
Tamarix ramoisissima	Asia	x				x	x	see text
Verbena bracteata	Native				?	x		desert waste places-0
Tribulus terrestris	Old World				x	x		Salton Sink-C(1); campgrounds,JTNM(5); "a serious pest"
Zygophyllum fabago	Old World	?	?	?				Muroc,Rosamond 1935 (2);Blythe-R
Pistia stratoites	Native						x	nr.Yuma
Washingtonia filifera	Native						x	natur. in Kern Co; see text
Cyperus esculentis	Old World		?			x		nr.Mecca(1);noxious weed of gardens and low places
Scirpus robustus	Wyoming?						x	Imp.V.,Ft.Yuma-C(1); AS-C
Juncus torreyi	Native?					x	x	Mecca-A(1)
Agropyron desertorum	Russia, about 1880	x						SS,Inyo Co.rangeland. possibly not in CDCA (2)[not in Munz]
Arundo donax	Europe						x	Alg.Dunes area(4); ditches&seeps in des.
Avena fatua	Europe		x	?	?	x	x	Brawley-R(1);Alg. dunes canal banks(4); common weed
Bromus arenarius	Australia	?				x		Shoestring Mine,Ant. V.1914,Ivanpah Mtns. &Barstow,1915(2); widely spread overD.
Bromus diandrus	Europe		x	x		x		Moj.D.1915(2);common weed
Bromus rubens	Europe	x	x			x		PalmSpr.1913,Moj.D. 1915(2);RodmanMtn. (11);ChemehueviMtns. (12);Moj.&Colo.D.-C

Habitat(s)

Scientific name (common name)	Country of origin	undisturbed	irrig.flds.	ab'd fields	roadsides	gdns/towns	canalbanks	Distribution/ source/date
Bromus tectorum	Medit.area	x						e.side, Sierra Nevada (2); common weed over 3000'
Bromus trinii	Chile?	x						dry plains&slopes(2)
Bromus unioloides	S.America	?	?	?	?	?	?	weed-O
Bromus willdenovii	S.America	x	x		x	x		Moj.D.roadsides, Barstow, Panamint V.(2); weed-O
Cenchrus carolinianus	?	?	?					n.e.of Mecca-R(1); [not in Munz]
Cenchrus echinatus	Native	?						Imp.&S.D.Co.weed
Cenchrus incertus	Native					x		weed, Daggett
Cenchrus longispinus	e.US	?				?		desert weed-R
Chloris virgata	Trop.Amer.		x			x		Imp.&Cch.V.-C(1);des. waste areas-O
Cynodon dactylon	Old World		x			x		Imp.&Cch.V.-C(1)
Cynodon maritimus	?		?			?		Imp.V.-C[not in Munz]
Cynodon transvaalensis	Europe		x			x		Bard;escape from lawns
Dactyloctenium aegyptium	Old World					x		Calexico,1968
Distichlis spicata	Native		x	?				troublesome weed (10,p.53)
Echinochloa colonum	trop.&sub-trop.regs.	?	x					Imp.V.-C(1);weed, widely scattered inD.
Echinochloa crusgalli	Old World		x			x		Imp.&Cch.V.-F(2);
Eragrostis cilianensis	Europe	?				x		n.w.of Mecca-R(1)
Eragrostis diffusa	Native					x		Imp.Co.weed
Eragrostis neomexicana	Europe					x		desert waste places
Eriochloa gracilis	Native		x					Imp.,Riv.&S.B.Co.
Festuca octoflora	Native?	x						ChemehueviMtns.(12)
Hordeum gussoneanum	Europe					x		ShoestringMine,Ant. V.1914(2)
Hordeum leporinum	Europe		x			x		DeathV.area
Lolium perenne,ssp. perenne	Europe					x	x	Alg.Dunes canalbanks (4)

Scientific name (common name)	Country of origin	undisturbed	irrig. flds.	ab'd fields	roadsides	gdns/towns	canalbanks	Distribution/ source/date
		Habitat(s)						
Muhlenbergia microsperma	Native	x	?	?	?	?	?	CBS-C at low elevs.
Paspalum dilatatum	S.America				x	x	x	Victorville
Paspalum distichum	Native?						x	Imp.V.-O(1)
Phalaris paradoxa	Medit.area		?			?		Imp.Co.-O
Poa annua	Europe					?	?	onMoj.D.,1906,Granite Wells 1915(2)
Polypogon monspeliensis	Europe	x	x			x	?	FurnaceCreek 1891, Ant.V.1893,Surprise Cyn.(Panamint area?) 1908;Mecca&Imp.Jct.-R(1913);Post Office Spring(1915);(2)
Schismus arabicus	s.w.Asia	x						w.Moj.D.-see text
Schismus barbatus	Old World	x				x		widely scattered-C; see text
Setaria glauca	Old World		x			x		Imp.&Cch.V.-O(1); desert-wide weed
Setaria viridis	Europe		x			x		weed,occasional but quite widely spread
Sorghum halapense	Old World		?			x		nr.El Centro-A(1); C in low waste areas
Sorghum lanceolatum	Trop.Afr.		x			?	?	nr.Bard-A
Sorghum sudanese	Native		x			?	?	nr.Bard-A
Sorghum virgatum	Native		x			?	?	nr.Bard-A
Halodule wrightii	s.e.US						x	on Salton Sea-C

APPENDIX B

VEGETATION REMARKS ON U.S. LAND SURVEY NOTES, SELECTED CDCA TOWNSHIPS

The following pages include the vegetation notations from various CDCA townships as selected by BLM Desert Planning Staff members. The following townships were selected, and are listed chronologically as follows:

1) T14N, R13E; 2 sheets (1 exterior, 1 interior)
2) T14N, R15E; 4 sheets (1 ext., 1 int., 1 both)
3) T14N, R16E; 3 sheets (2 ext., 1 both)
4) T12N, R18E; 3 sheets (1 ext., 1 int., 1 both)
5) T12N, R19E; 3 sheets (1 ext,, 2 int.)
6) T10N, R18E; 3 sheets (2 ext., 1 int.)
7) T13S, R10E; 1 sheet (int.)
8) T14N, R1E; 1 sheet (int.)
9) T13N, R1E; 5 sheets (4 ext., 1 int.)
10) T11N, R14E; 3 sheets (2 ext., 1 both)
11) T11N, R15E; 3 sheets (1 ext., 1 int., 1 both)
12) T10N, R5E; 3 sheets (2 ext., 1 both)
13) T9N, R5E; 3 sheets (ext.)
14) T9N, R6E; 4 sheets (3 ext., 1 int.)
15) T9N, R21E; 5 sheets (ext.)
16) T11N, R11W; 2 sheets (1 int., 1 ext.)
17) T11S, R13E; 2 sheets (1 int., 1 both)

NOTE: All townships are located within the San Bernardino Base and Meridian System.

The charts, designed especially for this project, are easy to read. They are intended to record the vegetation along a section line (or township line, if the hexagons around the outside of the page are filled in). When the notes along a <u>north-south</u> trending line are marked, they are noted in the numbered rows; the section line between secs. 8 and 9, for instance, is marked between the tic-marks that show

5 | 9 and 8 | 16.

When the notes along an east-west trending line are marked, they are noted in the non-numbered rows. The section line between secs. 9 and 16, for instance, is marked in the hexagon between the tic-marks that show

$$\begin{array}{c|c} 8 & \\ \hline & 16 \end{array} \quad \text{and} \quad \begin{array}{c|c} 9 & \\ \hline & 15 \end{array}.$$

When the surveyor has given no data on an area, the symbol (ø) is given.

Other common abbreviations are;

gr. - growth
U.g. or u/g - undergrowth
n.t. - no timber

Information copiers (all WESTEC Services employees) were:

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In some areas, vegetation comments were made at the section corner, as well as along the section line. In these cases, heavy lines have been drawn to (or close to) the appropriate section corner. Comments on the entire township are included on the bottom and/or back of the interior-coverage forms; these often include much data not available in the section-line comments.

Comments concerning obvious vegetation change are included in blue ink on the township sheets, and in the summary. Differing styles of interpretation among surveyors do not allow more definitive comments.

3. T11N, R15E, SBM:
   1857 to 1918-22 surveys -- appears to be much cactus, and some pinyon and juniper invasion. Large loss of grass cover.
4. T10N, R5E, SBM:
   Changes not recorded; no duplication.
5. T9N, R5E, SBM:
   1856 to 1911 surveys -- Comparison valid only for grass growth. Grass along Eastern edge appears to have significantly deteriorated.
   1856 to 1920 surveys -- Comparison invalid. One noted grass only, the other only shrubs.
6. T9N, R6E, SBM:
   1855 to 1911 surveys -- Small, poor sample along north and south border suggests significant grass reduction.
   1911 to 1920 surveys -- No vegetation change noted.
7. T9N, R21E
   1855 to 1883 surveys -- No comparison along east edge; no vegetation comments made in 1855 survey.
   1883 to 1911-22 surveys -- In southeast corner of twp, "dense greasewood" becomes "scattering greasewood."
   1883 to 1923 surveys -- Catclaw and Spanish bayonet noted as new species along southern border. Appears to be due to more detailed note-taking. Along Eastern border, many new species appear; 1883 "sagebrush" notation appears inaccurate, as N.E. end of twp. noted with greasewood in 1855 and 1923.

Non-Use Areas

1. T11N, R11W, SBM:
   1856 to 1933-34 surveys -- Grass appears to have deteriorated. Possible loss of palmetto as well.
2. T11S, R13E, SBM:
   Changes not recorded; no duplication.